ARQ 10
SPRING 1997

THE JOURNAL OF THE DEFENSE ACQUISITION UNIVERSITY

DEFENSE ACQUISITION UNIVERSITY
EXCELLENCE IN ACQUISITION

# ACQUISITION Review QUARTERLY

VOL. 4 NO.2

The ***Acquisition Review Quarterly*** is published quarterly for the Defense Acquisition University by the Defense Systems Management College Press, 9820 Belvoir Road, Suite G38, Fort Belvoir, VA 22060-5565. Periodicals Postage Paid at Fort Belvoir, VA and at additional mailing offices. Postmaster send changes of address to: Editor, ***Acquisition Review Quarterly***, Defense Systems Management College Press, 9820 Belvoir Road, Suite G38, Fort Belvoir, VA 22060-5565. For free copies, submit written requests to the above address. Articles represent the views of the authors and do not necessarily reflect the opinion of the Defense Acquisition University or the Department of Defense. ISSN 1087-3112.

The ***ARQ*** is available electronically on the DSMC Home Page at **http://www.dsmc.dsm.mil**

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*



| 1. AGENCY USE ONLY *(Leave blank)* | 2. REPORT DATE | 3. REPORT TYPE AND DATES COVERED |
|---|---|---|
| | Spring 1997 | Refereed Journal |

**4. TITLE AND SUBTITLE**

Acquisition Review Quarterly (ARQ)
Vol. 4, No. 2

**5. FUNDING NUMBERS**

**6. AUTHOR(S)**

Numerous Authors

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**

Defense Systems Management College
Attn DSMC Press
9820 Belvoir Road
Suite G38
Fort Belvoir, VA 22060-5565

**8. PERFORMING ORGANIZATION REPORT NUMBER**

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**

Defense Acquisition University
2001 N. Beauregard Street
Alexandria, VA 22311

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**

Distribution Unlimited

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicing acquisition professionals with relevant management tools and information based on recent advances in policy, management theory, and research. The ARQ addresses the needs of professionals across the full specturm of defense acquisition, and is intended to serve as a mechanism for fostering and disseminating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decisions, and for maintaining a high level of awareness regarding acquisition management philosophies.

**14. SUBJECT TERMS**

Best Value Source Selections; Review of Literature; Acquisition Process Metrics; Acquisition Strategy; DoD Acquisition Process; Cost as an Independent Variable

**15. NUMBER OF PAGES**

242

**16. PRICE CODE**

| 17. SECURITY CLASSIFICATION OF REPORT | 18. SECURITY CLASSIFICATION OF THIS PAGE | 19. SECURITY CLASSIFICATION OF ABSTRACT | 20. LIMITATION OF ABSTRACT |
|---|---|---|---|
| Unclassified | Unclassified | Unclassified | Unlimited |

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

# ACQUISITION Review QUARTERLY

**Spring 1997**
**Vol. 4, No. 2**


## TABLE OF CONTENTS

## LESSONS LEARNED

# A DECISION SUPPORT PROCEDURE FOR BEST VALUE SOURCE SELECTIONS

*Michael F. O'Connor, Janine L. Faris, and Joan S. Lovelace*

Here we discuss the use of decision analytic procedures in Best Value source selections. Such source selections specifically require that choosing an offeror other than the one with the lowest assessed cost must be justified by showing that the added value of that offeror's proposal is worth the associated extra cost to the government. Such a demonstration implies cost–benefit tradeoffs with an associated issue of benefit quantification during the source selection. This article is written for two audiences. One is acquisition practitioners who are implementing an acquisition program that will employ a Best Value source selection. We aim to familiarize this audience with relevant decision analytic tradeoff procedures and with important methodological problems. This article will familiarize the second audience, decision analysis practitioners, with an important problem for which their tools are highly relevant. We will describe the Best Value process, provide an illustrative procedural template, and discuss methods for required cost–benefit tradeoffs. The report also addresses legal issues in Best Value source selections. Finally, the report presents lessons learned based on the authors' experience in Best Value acquisitions.

Source selection is the formal process by which the government makes procurement decisions for acquisitions. At different stages of an acquisition, sources (contractors) are chosen to develop concepts, to conduct studies, to develop systems, to produce a system, or to provide services. Decision issues are not separated by the artificial barriers created by the sequenced programmatic approach, but instead transcend those boundaries. Decision support procedures and tools should help link each decision to the ultimate benefits and costs associated with the eventual decision outcomes.

## THE PROCESS

In the Best Value approach to source selection, the Source Selection Evaluation Board (SSEB) makes its report to the Source Selection Advisory Council (SSAC), designating evaluation results for those offeror proposals in the competitive range. The SSAC, unlike the SSEB, can actually compare the offeror proposals against each other. The award is then made to the "most advantageous alternative to the government." The Best Value comparison process is triggered if that proposal with the lowest total cost is not also considered to offer the greatest benefit to the government (Federal Contracts Report, 1993; Sochon, 1994; USGSA, 1992). It must be noted that the so-called Best Value approach does not implement anything that was not already permissible under the Federal Acquisition Regulation (FAR, 1993). However the strong precedent for competition and choosing the lowest bidders, and the fear of the tremendous costs and associated damage caused by the program delays that occur with protests, require clarification of this procedure. The Best Value variation of source selection generally proceeds as follows:

- The SSAC members (or a special Best Value team assisting the SSAC) compare the offeror proposals (not the proposal scores) based on the information provided them in the report and briefings by the SSEB.

**Michael F. O'Connor**, Ph.D., is a lead scientist in the Economic and Decision Analysis Center of the MITRE Corporation specializing in the application of decision analytic techniques to complex organizational decisions for DoD and other government organizations. He has applied these techniques for more than 20 years to program design decisions, system design and acquisition decisions, budgeting decisions, policy decisions, and planning exercises. He has recently focused on Best Value source selection decisions. He received a Ph.D. in mathematical psychology from the University of Michigan. He has taught at several universities including the University of Southern California, the University of Chicago, George Mason University, and the George Washington University.

**Janine L. Faris** is a principal member of the technical staff in the Economic and Decision Analysis Center of The MITRE Corporation in McLean, VA. She is responsible for product quality, program development, staff development, and technical support in the delivery of consulting services for acquisition support and economic analysis to multiple projects for high technology programs of the federal government. Recent clients include the Defense Information Systems Agency (DISA) and the Director of Defense Research and Engineering (DDR&E). Faris's previous position at MITRE was as a group leader for the Resource Analysis Group. She holds an M.B.A. degree from Loyola College, a B.A. degree from Antioch College, and a Certificate in Procurement and Contracts Management from the University of Virginia. Faris is a certified cost estimator/analyst through the Society of Cost Estimating and Analysis (SCEA).

**Joan S. Lovelace** is currently a department head for the Business and Economic Analysis Center in Mitretek Systems, Inc. She is a graduate of the Defense Systems Management College's Program Management Course. She has served as the National Conference Program Chair for the Society of Cost Estimating and Analysis, and is currently president of the Washington Chapter of SCEA. She is a member of the International Society of Parametric Analysts and is a former editor of the *Journal of Parametrics*. She holds a B.A. degree in American studies from Beloit College, an M.A. degree in history from Claremont Graduate School, and an M.S.L.S. from Catholic University.

- Discriminators (i.e., relative advantages that one proposal has over another) among the proposals are established through this comparative process. Discriminators will relate to one or more of the evaluation factors used in the SSEB evaluation process and must be traceable to those factor evaluations.

- Impact areas of the discriminators are defined—that is, the benefit areas affected by the discriminators. A discriminator might be some aspect of the offeror's technical approach to an important system capability. The associated impact area would be some aspect of conditional expected performance. (Note that benefits are assigned to impact areas, not to the discriminator differences.) The benefit assessment is thus a prediction, and assessment procedures must consider the uncertainty involved.

- Discriminator impact areas are often characterized in Best Value methodology descriptions as either "quantified" or "nonquantified." The term "quantify" is ambiguous. Procedurally, in source selections, it usually means to assign dollar values to levels of the variable to be quantified. To engineers it seems to mean to assess on an interval or ratio scale. For example, a quantified discriminator impact area might be "expected payload." A non-quantified (sometimes called "qualified") discriminator impact area might be "expected program management efficiency." Such distinctions are not very useful from a measurement theoretic point of view, but can have strong implications as used in the currently defined acquisition process. Furthermore, as indicated, these benefit impacts are uncertain, and the uncertainty must be characterized (even if it can't be directly quantified).

- The benefits associated with the impact of each discriminator are described using as much clarity of definition and precision of assessment as is feasible. As indicated, benefits are assessed for predicted impacts, and the expectation and uncertainty should be assessed.

- The benefits associated with quantified discriminators are traded off against the total cost to the government (not simply contract price). These total cost estimates should be adjusted for cost risk (also characterized as cost realism). As indicated, the described tradeoff translates benefits to dollars. Less stringent tradeoff requirements allow for systematic judgmental assessments of the worth of the benefits relative to each other and relative to cost. The tradeoff process depends on the implementation method chosen. At this point, a single, well-defined requirement for the scalar aspects of the tradeoff process has not been defined. Several alternatives are discussed in the next section.

- Nonquantified benefits associated with discriminators are also used. Although these benefits are used only as tiebreakers by some agencies, they can be traded off against other benefits or costs, which is the procedure recommended here.

- The resulting implications are examined by the SSAC and a decision is recommended to the Source Selection Authority (SSA).

## Variations of the Approach

Several methods for trading off cost and benefits in Best Value decisions have been described. Four are reported here, but for the reasons explained below, only methods 2 and 3 are recommended.

1. Dollar cost to obtain increased benefit. In this method an estimate is established of the cost to provide from the lower cost, lower rated technical proposal a benefit of comparable magnitude to that associated with the higher rated technical proposal. How could the lower cost proposal be best upgraded to achieve the key benefits (as indicated by discriminator impact areas) of the higher rated technical proposal, and what would be the cost to do so? This adjustment should be in terms of the most probable total cost to the government and should adjust for cost realism and for discounted cash flow. The decision would then be made in terms of the adjusted cost figures. The idea seems simple. If the cost to provide the added benefit is less than the actual cost difference, then the added benefit of the higher rated technical proposal is not worth its added cost. Thus the lower bid provides the greatest value in a cost–benefit sense. This procedure does not suggest "technical leveling" (i.e., to actually transmit the ideas to the lower bidder). It is simply a cost estimating methodology designed to answer the Best Value question.

   A potentially serious problem with this procedure is that the technical approaches of the offerors may be so different that the cost to change the lower cost, lower rated technical proposal to provide the technical benefit of the higher cost, higher rated proposal is prohibitively large, or cannot be reasonably calculated, indicating choice of the higher rated proposal. Yet, the government may assess that the perceived value of the benefit associated with this technical superiority is minimal, less than the cost difference and it clearly would not pay this difference. This indicates that the lower bidder should be chosen. It also shows that this tradeoff method can produce different results from the following two methods. The cost to provide a benefit is not necessarily a valid indication of the value of the benefit to the decision maker as reflected by "willingness to pay" (see Discriminator Benefit Tradeoff method). This method consequently is not usually a desirable approach from a decision analytic point of view; we do not recommend it here.

2. Direct discriminator impacts benefits quantification. The direct discriminator impacts benefits quantification involves directly assessing the value to the government of the effects associated with discriminator advantages of each offeror. For each discriminator, the impact area is identified and an attempt is made to directly quantify the benefit of the impact using a model, an established methodology, a surrogate index, or some other measure that characterizes the benefit of the impact. An example would be increased productivity of a workforce attributable to increased user friendliness of computer

workstations. A discriminator can be unique to a particular offeror, or several offerors' proposals may have potential impacts with respect to a discriminator. All important discriminators are quantified where possible.

An important consideration related to this and the procedure described is that generally in offeror comparisons, each offeror has one or more advantages over other offerors. Thus the lowest bidder may also have several benefit advantages over the higher bidder even though the preponderance of benefits clearly lies with the higher bidder. Once discriminator impacts have been quantified for all offerors, costs are appropriately adjusted for each offer to yield adjusted net values. (See "A Procedural Example" for more information on the procedure and terminology.) A practical issue is that some discriminators cannot be quantified,[1] and some discriminators can only be partially quantified. When this occurs, the nonquantified discriminator impacts can be traded off against quantified ones using the third procedure discussed here, or they can be used as the breakers.

3. Discriminator benefit tradeoff. In this method the SSAC determines the relative value of the increased benefits associated with the technically superior proposal in direct tradeoffs, in which described benefits are directly compared pairwise using ordinal preference or ranking type assessments. "Willingness to pay" is often used as a preference assessment method. All attribute differences or advantage impacts among alternatives become "benefits" for tradeoff in this approach. If there are more than two offerors in the Best Value comparison, as is usually the case, benefits are traded off for each pair of offerors. A rank ordering of the benefits can be established using this process which can also provide consistency checks. A version of the process is described in the example approach presented in the next section. Tools such as Multi-Attribute Utility Theory (MAUT) or the Analytic Hierarchy Process (AHP) can be used in establishing such an ordering. These tools, if employed using appropriate axiomatic tests, can provide interval level utility assessments. The results of the discriminator benefit tradeoff method are likely to differ from those of the first method described. At the same time, the ordering of options derived from this approach should agree fairly well with those of the second method, and should provide a valid representation of the decision maker's values.

4. Point scoring. In this method, price points and technical points are assigned in a manner established in the Source Selection Evaluation Plan (SSEP) and described in the Request For Proposals (RFP). This procedure when used by the SSEB can be somewhat restrictive and is usually avoided in source selections for this reason. Assigning points to discriminator advantages proportionally to the weights of evaluation criteria on which the advantage is based may not validly quantify the value of the resultant benefits associated with discriminator impact areas, thus misrepresenting discriminator benefit. These relative benefits must

still be established and justified as a meaningful difference to establish Best Value, for as indicated, discriminators need not be the actual evaluation criteria of the SSEP. If points are assigned that actually represent the value of the discriminator impact to the government, this accomplishes the same result as the tradeoff approach of methods 2 or 3 above (which must still be used to assure consistency), and the approach is simply a variation of one of those. Attempting to assure that the resultant benefit assignments do not violate implications of the point distribution rules set forth in the SSEP and partially explained in the RFP is very difficult, especially if a discriminator relates to more than one evaluation criterion. The ordering of the impact benefits thus derived can thus potentially be different from what might be expected from the ordering of the importance of weights assigned in the RFP. It's a good idea to examine the implications of such cases as a check on the analysis, but that should be the extent of the procedure.

## A Procedural Example: The Best Value Assessment Plan For System X Source Selection

Here we give an example of the general approach to Best Value for the hypothetical System X source selection. The approach is based on accepted practice, the legal and procedural rulings with respect to Best Value procurements, and certain assumptions about quantification. This approach is to be implemented when the SSEB evaluation has been completed and the issue of Best Value must be addressed by the SSAC. Because the crucial question is overall value to the government, certain steps related to cost realism and risk are included. This is a specific example, and variations dependent on procurement conditions are quite appropriate (see Faris and Lovelace, 1994, for further discussion). It also tries not to do violence to current practice while still inserting accepted, valid assessment techniques into the process. The treatment of uncertainty assessments and cost–benefit tradeoffs is necessarily abbreviated and other variations using benefit and cost ranges are acceptable.

### Recommended Steps

**Step 1. A Best Value working group (BVWG) is formed.** This is done after SSEB reports are finished. This BVWG should be small, but the group in aggregate should represent complete knowledge of proposal cost, management, and technical content (as well as any special evaluation areas, e.g., software capability evaluation [SCE]). The BVWG should serve in an advisory role to the SSAC. BVWG members should be familiar with the evaluations done by the SSEB and the summary report preparations, and they need access to all relevant information. Initially the BVWG can be formed mostly of those familiar with the SSEB evaluations in order to efficiently define discriminators. Then a subset of SSAC members may join to enhance the identification of impact areas and associated benefits.

**Step 2. The BVWG reviews the cost realism information.** The BVWG should review cost realism work done and pre-

pare the relevant information in a tabular format. If the required information is not available, the BVWG should prepare the information from data provided by the SSEB.

This cost information should include all adjustments to price and cost to reflect an accurate assessment of the true total cost to the government of the offeror's proposal (sometimes denoted as the "government's most probable cost," or GMPC). Adjustments made to the offeror's cost can be to correct arithmetic errors, adjust inappropriate labor mixes, or to reflect technical or management-related risks that will affect the effort or schedule required to deliver the capability as proposed. (See Carroll, 1994, for further discussion.)

Where schedule adjustments are made, they are also quantified as part of a cost realism assessment. Both schedule and cost risk are determined by the major uncertain events in the program life cycle, some due to the nature of the offeror's proposal and some external to the proposal. Costs are conditional on schedule, and uncertainty assessments must accommodate such dependencies. One must therefore carefully integrate cost and schedule realism assessments.

Another consideration involves the use of the total acquisition cost of the program to the government as a second cost metric, in addition to the life-cycle cost, for comparing different offeror proposals. When schedule corrections are made, any impact on the government effort (including support personnel) required to manage the program can also be accounted for and included in an adjusted total cost number. This assessment can be difficult for some contracts involving large support structures, and if a simplified approach is chosen for that reason, it must be evenhanded with respect to the evaluations of all offers.

Risks external to the offeror's proposal but part of the system life cycle and thus the total cost to the government are often included as quantified (or qualified) risks. Such a risk could be due to some event (e.g., a technology requirement upon which the system employment is dependent) that causes uncertainty unique to the offeror's approach to the program, and for which a specific program cost assessment cannot be reasonably made. This partitioning of risks can be a matter of preference. The impact of all risks that can be quantified can be included in this cost realism adjustment, both program internal and program external risks. The desire is that the resulting number be a realistic estimate of the most probable life-cycle cost to the government of choosing the offeror in question to provide the desired capability or system. A caution is that risk inclusion should be accomplished evenhandedly so that all important risks are included for all offerors during the same period.

**"A caution is that risk inclusion should be accomplished evenhandedly so that all important risks are included for all offerors during the same period."**

All adjustments to proposed cost or price should be recapped in tabular format and supported by descriptive methodology detailing the logic and providing an audit trail (Table 1). A separate but related table should account for uncertainty in the adjustments made by indicating the uncertainty ranges associated with the as-

**Table 1.**
**Cost Realism Table**

| Cost Realism Assessment ($M) | Offeror X1 | Offeror X2 | Offeror X3 | Offeror X4 |
|---|---|---|---|---|
| 1. Proposed cost (for proposed effort) | $54.5 | $59.3 | $65.0 | $50.2 |
| 2. Arithmetic cost adjustment (for errors, omissions, etc.) | 0.5 | 0.2 | 0.0 | (0.2) |
| 3. Cost adjustment of offeror effort. This adjustment results from an independent assessment of technical/management effort required to deliver the system as proposed by the offeror. | 1.2 | 0.7 | 1.5 | 3.0 |
| 4. Cost adjustments due to technical and/or management risks. These will impact the delivery schedule or effort required to deliver the proposed system as scheduled; they can be due to overly optimistic schedule assumptions, complex technical interdependencies not accounted for in the proposed effort, and the like. | 6.0 | 2.5 | 1.0 | 8.0 |
| **Total - cost realism assessment** | **$62.2** | **$62.7** | **$67.5** | **$61.0** |

sessments. An appropriate confidence interval (e.g., 80 percent) should be consistently used for discussions of uncertainty. The choice of an 80 percent confidence interval instead of, say, a 95 percent range, itself reflects a tradeoff. The important point is that cost adjustments are uncertain assessments, and the magnitude of the uncertainty should be indicated to decision makers.

**Step 3. The BVWG works with the SSAC to establish discriminators.** The BVWG reviews the technical, management, and cost evaluations. In doing so, the BVWG reviews offeror strengths and weaknesses with respect to the evaluation factors as summarized by the SSEB evaluation final reports. The BVWG conducts a comparative evaluation of these offeror strengths and weaknesses to identify comparative advantages and weaknesses associated with each offeror's proposal. These advantages and weaknesses identify discriminators among offeror proposals.

Each discriminator is traced to the evaluation factor(s) from which it is derived and these discriminator/evaluation factor links are listed. The impact area of each discriminator is also listed. This is the potential programmatic or operational benefit (or risk) associated with the discriminator. For each discriminator identified for each offeror, the impact(s) are described in sufficient detail to support the resultant benefits assessment, and provide summary rationale for the benefit. Ben-

efits could include reduced system down time or enhanced interoperability with other Department of Defense (DoD) systems. Technical or management risks that are related to events beyond the control of the offeror and that thus were not previously accounted for in cost realism adjustments can also be included here as discriminators. As indicated earlier, when discriminator impacts and issues of quantification are addressed, it is beneficial to involve some SSAC members. The appropriate member depends on several factors relating to efficiency and validity of the process. Using the benefit description developed, one makes a determination concerning which discriminator impacts can be quantified (e.g., as a potential cost avoidance in development, as a cost savings in program management and thus program costs, as a cost savings in operations and support, as an operational benefit that can be partially quantified, as a quality, capability enhancement). Nonquantifiable benefits and risks developed in the above description are listed with supporting rationale. These can be recapped in tabular format (Table 2).

**Step 4. A benefits summary table is prepared.** This table relates the offeror benefit checks in the above table to a benefits reference summary, which should describe in detail the rationale for the benefit claimed for the offeror. This latter description should be systematic and should include referenced precedents, studies, similar systems, and any other relevant information used to assess the benefit associated with the discriminator. If the ben-

**Table 2.**
**Discriminator Impacts Table**

| | | | | | Offerors | | | |
|---|---|---|---|---|---|---|---|---|
| Discriminator | Impact area of discriminator | Evaluation factor from which discriminator is derived (can be more than one). | Quantitative? Indicate if benefit can be, or has been quantified. | Qualitative? Indicate if benefit cannot be quantified and is supported only by descriptive rationale. | X 1 | X 2 | X 3 | X 4 |
| 1. Key personnel | P, M, C | Management | | X | + | + | | |
| 2. Early delivery | P, C | Technical/ overall | X | | + | + | | |
| 3. Past performance | P, M | Related experience | | X | – | + | – | + |
| 4. Training | P | Management | X | | + | + | + | |

*P = productivity, M = mission effectiveness, C = cost. No entry means no impact, + indicates a positive impact for the offeror, and – indicates a negative impact or risk for the offeror.

efit will be quantified, this should also be indicated. The benefits summary table contains a very brief summary of the conclusions to be drawn.

**Step 5. The BVWG quantifies the benefits listed as quantifiable in the discriminator impacts table (Table 2).** These benefits are quantified and inserted into the appropriate cells for appropriate offerors in the quantified benefits table below. The methods for quantification can include analyses specific to the impact area, use of a particular cost or related model identified early in the source selection process, or use of some logically developed algorithm. Generally, these benefits will be positive, reflected as deltas above the offeror scoring lowest overall on the evaluation criterion (or criteria) linked to that discriminator. The benefits summary table or a similar report indicated in Step 4, explaining the basis of each and every predicted benefit, is prepared and referenced. The explanation includes the logic for the quantification method chosen, referenced precedents, studies, information sources, etc. A description of the procedure should be provided sufficient to facilitate a clear understanding of how quantification of the benefit was accomplished.

At this time, the BVWG also quantifies those technology and business risks, identified in the discriminator impact table, that can be quantified. As indicated, these may be due to potential events outside the offeror's control that can occur at any point in the system life cycle, or they can be risks that have not yet been considered in the evaluation process. This means that the risks are based on information that has not already been accounted for in the cost realism adjustment made (Table 1) described in Step 2. Where possible, and if appropriate, the potential impact of the identified risk is quantified as a cost impact on the program. These most probable quantified technical or management risks are also inserted into the appropriate cells in Table 3. Generally such risks will have a negative value—that is, they are "negative benefits" or "disbenefits" which will thus increase the overall total cost to the government.

The impact of particular technical or business risks are uncertain, and the BVWG can assess the range of potential cost impacts from the minimum to a maximum figure for each individual risk. As indicated, the most probable value is inserted in the table as a point estimate; however, an appropriate cumulative probable

**Table 3.**
**Quantified Benefits Table ($M)**

| Discriminator impact (Quantified benefits from Table 2) | Offeror X1 | Offeror X2 | Offeror X3 | Offeror X4 |
|---|---|---|---|---|
| Early delivery | $1.5 | $2.5 | – | – |
| Training | $2.0 | $2.0 | $3.0 | – |
| Summed quantified benefits | $3.5 | $4.5 | $3.0 | $0.0 |
| Cell entries $ benefits [($) if negative] | | | | |

impact, such as 80 percent (probability is 0.80 that the cost impact will be that amount or less) can also be assessed as a more conservative or risk-averse estimate. Both the most likely and 80 percent cumulative probable estimates can be used in later summaries. It should be indicated which is being used, and use should be consistent.

**Step 6. A net value summary table is prepared.** The "net value" is a number used for comparative purposes only and will not correspond to a true price or life cycle cost (see Table 4). It provides for systematic benefit and cost comparisons that take account of not only the realistic predicted cost to the government of the system but also of the benefits associated with the offerors' respective proposed systems. Positive quantified benefits are subtracted from an offeror's projected cost in this table. Risks that are potential expected losses are added to cost.

That offeror with the lowest net value represents the Best Value at this point in the analysis. The quantified benefits have been considered in the analysis and the net value is the result. The nonquantified benefits must still be considered, and these may or may not change that offeror considered the Best Value.

**Step 7. A nonquantified benefits evaluation and summary is prepared.** This is done for those benefits and risks listed as nonquantifiable in the discriminator impacts table. The nonquantifiable, or qualitative, discriminator impacts can then be detailed in another table in the same order for each offeror. See Table 5 for an example. The rank order can be a consensus rank order developed by the SSAC of the relative importances of the nonquantified discriminators based on the descriptions of likely impacts. Since quantification of impact benefits has not been accomplished, precise weights cannot be assessed. However, for each discriminator, the SSAC can establish a rank order of offeror proposals in terms of likely impacts with respect to that discriminator. These rank orders are indicated in the table.

*Comparison to quantified benefits.* One method for further precision in assessing the relative benefits of the nonquantified benefits is a comparison of each of these

**Table 4.**
**Net Value Summary Table ($M)**

| | Offeror X1 | Offeror X2 | Offeror X3 | Offeror X4 |
|---|---|---|---|---|
| Original bid price | $54.5 | $59.3 | $65.0 | $50.2 |
| Cost realism adjustment to price | +7.7 | +3.4 | +2.5 | +10.8 |
| Most probable cost to the government | 62.2 | 62.7 | 67.5 | 61.0 |
| Sum of quantified benefits and risks | − 3.5 | − 4.5 | − 3.0 | − 0.0 |
| "Net value" of offer | $58.7 | $58.2 | $64.5 | $61.0 |

**Table 5.**
**Nonquantified Benefits Table**

| Discriminator | Discriminator Impact Area | Offeror X1 Benefit Explanation | Offeror X2 Benefit Explanation | Offeror X3 Benefit Explanation | Offeror X4 Benefit Explanation |
|---|---|---|---|---|---|
| Key personnel (KP) | Productivity mission effectiveness cost | Strong selection for program manager and software development manager<br><br>Denote as B(KP), X1 | Strong key personnel selections for all positions, particularly software development manager and planning manager.<br><br>Denote as B(KP), X2 | | |
| Past performance (PP) | Productivity mission effectiveness | Extensive relevant experience with like projects; this is offset by significant cost or schedule overruns<br><br>Denote as B(PP), X1 | Relevant experience with like projects and this agency<br><br>Denote as B(PP), X2 | Relevant experience with like projects and this agency, but history of significant cost or schedule overruns<br><br>Denote as B(PP), X3 | Relevant experience with like projects and this agency<br><br>Denote as B(PP), X4 |
| Position of offeror rank ordered benefits | | Rank 3 | Rank 1 | Rank 4 | Rank 2 |

nonquantified benefits to those that have been quantified, thus bracketing nonquantified benefit values between the values of those that are quantified. Which is worth more to the government, the nonquantified benefit or the quantified benefit? For a particular offeror benefit, a pair of quantified benefits is found such that the nonquantified benefit is worth more than one benefit and less than the other. These benefits can be any from the list of quantified benefits (if there is a sufficiently large set). Assign the nonquantified benefit a dollar value between the quantified values. If desired, these could be integrated with the quantified benefits in the net value table, or they can be inserted in the nonquantified benefits table (Table 5).

*Direct comparison of nonquantified benefits.* Nonquantified benefits can also be directly compared to each other using

an iterative, stepwise process. There are numerous procedures for such comparative evaluations involving the ordinal properties of the benefits. For example, in comparing the benefits of Offerors 1 and 2, first the relative magnitudes of the nonquantified benefit items of each offeror are rank-ordered relative to each other without comparing to those of the other offeror. Then the smallest benefit item (or largest) of one offeror is compared to the smallest (or largest) benefit item of the other. A decision is made as to which item is worth more to the government and why. The reasons for the decision are recorded. Then, for the offeror whose smallest benefit item is the lesser of the two, his smallest two benefit items are compared to the smallest of the other offeror. These two must either be worth more or less than the smallest item of the other offeror. If less, the third smallest item is added. If larger, the other offeror's second smallest benefit item is added to his first and the process is continued. Eventually, the benefits of each offeror will be ordered relative to those of the other offeror and there will be an advantage for one of the two. This is done for each pair of offerors (if necessary). Actually there will be many shortcuts in this seemingly tedious procedure, and it will not require as much time as initially anticipated.

A comparison of the nonquantified benefits listed Table 5 indicates that:

B(PP), X2 equals approximately B(PP), X4

B(PP), X4 is significantly greater than B(PP), X1

B(PP), X1 is slightly greater than B(PP), X3

B(KP), X2 is greater than B(KP), X1.

These inequalities imply that:

B(PP), X2 + B(KP), X2 > B(PP), X1 + B(KP), X1.

Similarly, further direct comparisons of these nonquantified benefits indicate that

B(PP), X4 > B(PP), X1 + B(KP), X1
B(PP), X1 + B(KP), X1 > B(PP), X3.

By aggregating the inequalities, it can be deduced that the order of the nonquantified benefits of the offerors is X2 – X4 – X1 – X3 as indicated in the bottom row of Table 5. Because Bidder X2 has the best overall net value prior to the nonquantified benefits comparison, and given the dominance by X2 in the nonquantified benefits, X2 remains the best overall net value.

**Step 8. Quantified and nonquantified benefits are traded off.** After the nonquantified benefits are compared, one of two situations will exist. The offeror with the lowest quantified net value may also have the greatest nonquantified benefits ranking. If so, the process is finished and that offeror is recommended. If the offeror with the greatest total nonquantified benefits ranking does not have the lowest net value, nonquantified benefits must be traded against quantified benefits using the process described in Step 7.

The comparison can be accomplished in several ways. One way is to again pro-

ceed pairwise. The offerors are ordered in terms of the net value results. The process starts with the lowest net value offeror. The net value difference between this and the second offeror is a benefit advantage over the second offeror. This net value advantage, in dollars, is compared to the nonquantified benefits directly. The net value difference may be more beneficial than the total of all of the nonquantified benefits of the second offeror or it may be possible to bracket it somewhere in the order. This pairwise comparison is accomplished iteratively and the results are integrated, interpreted, and summarized. The nature of the procedure should be fairly obvious; we won't discuss further variations. The point is that this comparative procedure provides a linked evaluation with the paired comparison ordering and reasons as supporting rationale for the results.

We can draw two conclusions. One is that this benefit comparison procedure is systematic, and although it depends only on ordinal preferences, it can be strongly supported by the benefits rationale prepared in the benefits summary table. The second is that the procedure is guaranteed to produce a recommendation. Though the procedure may seem very tedious, it can be made quite efficient. The important point is that ordinal ranking procedures that do not assume inordinate levels of precision can be used to produce the systematic evaluation desirable in Best Value procurements. The criticism that such assessments cannot be defended, and therefore should not be employed, does not make sense. If such judgments cannot be made, how can the decision made using some other less systematic approach be defended?

**Step 9. An overall best value summary table is prepared.** Finally, depending on the actual process used to compare nonquantified benefits, the BVWG must judge whether the results of this benefits comparison should change the offeror order in the net value table (see Table 6). A summary final rank order table is prepared indicating the nature of the final order with the systematic explanation of the benefits and costs audit trials that resulted in the ordering. This table contains the original

**Table 6.**
**Best Value Summary Table ($M)**

| | Offeror X1 | Offeror X2 | Offeror X3 | Offeror X4 |
|---|---|---|---|---|
| Original bid price | $54.5 | $59.3 | $65.0 | $50.2 |
| "Cost realism" cost | $62.2 | $62.7 | $64.5 | $61.0 |
| Net value adjusted for quantified benefits | $58.7 | $58.2 | $64.5 | $61.0 |
| Nonquantified benefits comparison results | Third highest aggregated nonquantified benefits | Highest aggregated nonquantified benefits | Fourth Highest (lowest) aggregated nonquantified benefits | Second Highest aggregated nonquantified benefits |
| Summary | Rank 2 or 3 | Best Net Value | Least Value | Rank 2 or 3 |

proposed price, the adjusted "cost realism" cost, the net value including quantified discriminator impact, and the nonquantified benefits from the nonquantified benefits table. The iterative stepwise process described above to reach the final decision can be explained proceeding through the related comparisons using this summary, with final remarks in the comments area. For the example here, the results of the comparative process are clear with respect to the best and worst overall net values. Because X2 is the best overall net value, it is not necessary to resolve the uncertainty about the ranks of X1, and X4. (The quantified overall cost (net value) for X4 is $2.3M higher than that for X1, but X4 nonquantified benefits are higher than those for X1. The question concerns the quantified value of these benefits. Do they compensate for the $2.3M? If this question needed resolution, the process described earlier would be used.)

## Legal Precedents; Protests of Best Value Decisions

Protests involving Best Value source selections have involved issues of improprieties, unfairness, improper procedures, failure to follow advertised procedures, and others. Several protests of Best Value procurements have involved the contention that the government didn't tell the offerors what it was going to do in sufficient detail to allow them to clearly state their case in the most advantageous way, or that the government did not do what it said it would do. The following are discussions of several relevant protests including non-DoD examples. (See GAO Review, April, 1994; GSBCA No. 12813-P-R {LEXIS 255}, 1994; Koch,1994; O'Keefe, 1978; and Sochon, 1994, for examples and discussion, and Widnall *v.* B3H Corp, 1996).) These protests demonstrate that the problem of an appropriate procedure for the crucial benefit to cost tradeoffs, the resolution of which should include practicing decision analysts, is in danger of being determined by legal precedents with respect to protests.

### Important Best Value Cases

**Cost realism adjustments.** The Treasury Multi-User Acquisition Contract (TMAC) (Koch, D., 1994) decisions established several precedents for Best Value procurements. One was that adjustments for cost realism and the projection of most probable life cycle cost to the government were acceptable practices. Also, there is no requirement in the law for technical factors to be proportional to cost factors. Technical factors can have a cost of their own expressed in terms of dollars irrespective of cost of acquisition and ownership considerations. TMAC also established that if no offeror protests the lack of information in the solicitation on the evaluation procedures prior to proposal submission, then there is no basis for a later protest based on this lack of information.

**Quantification.** In Grumman Data Systems Corporation *v.* Department of the Air Force (1992, Grumman), the Air Force used quantifiable and nonquantifiable discriminators. (See Federal Contract Report, 1994.) The quantifiable discriminators were translated to dollars. The importance of the nonquantifiable discriminators was stressed but not translated to dollars. This ruling upheld this version of tradeoffs but does not eliminate others. This tradeoff

process was also upheld in Computer Science Corporation (CSC) *v.* Department of the Army in the Army Reserve Component Automation Systems (RCAS) procurement (see Koch, D.1994, and GSBCA No. 11635-P, 1992 B.P.D. § 100). This Grumman protest also established the reasonableness of the cost technical tradeoff (CTTO) analysis by stating, "There is no formulaic methodology for conducting a Best Value determination; what matters is that the award is consistent with the terms of the solicitation and that any price premium is justified by the specific technical enhancements." (See Federal Contract Report, 1994.) Thus there is no necessary, defined formula for linking technical scores and cost. This link must be assessed. Because there is not one prescribed formula, other criteria such as "reasonable approach" and "evenhandedness" are appropriate for evaluating the linkage approach.

> **"There is no formulaic methodology for conducting a Best Value determination; what matters is that the award is consistent with the terms of the solicitation and that any price premium is justified by the specific technical enhancements."**

In Lockheed Missiles and Space Company *v.* Department of the Treasury, TMAC II (GSBCA Nos. 11776-P, 11777-P, 1992, B.P.D. § 155), the government failed to properly conduct present value and most probable cost adjustments on the estimated dollar value of the increased technical benefits in the Best Value assessment, but had done so on the original cost comparison. Lockheed recomputed the adjusted most probable costs based on the formulas used in the source selection, and the results favored a reversal of the decision. Nonetheless, the protest was denied. The General Services Board of Contract Appeals (GSBCA) determined that there were other values (e.g., nonquantified discriminator benefits) that the Treasury Department did not include in their analysis, and that these compensated for the error in benefits assessment. Note that this essentially means that GSBCA was itself assessing the value of benefits and also determining that nonquantified benefits do trade off against quantified benefits! The TMAC II ruling also upheld the use of the price–risk analysis discussed earlier.

**Clarity with respect to benefit tradeoff procedures.** The protest by System Resources Inc. (GSBCA No. 12536-P, 1993, B.P.D. § 253) was upheld, indicating that simply stating in the RFP that a Best Value approach will be used is not enough guidance. It must also be indicated that a benefit–cost tradeoff will occur. In this case, credit was given to an offeror's proposal for projected capability in excess of a threshold standard listed in the RFP, and offerors were not told that any such credit would be given. The RFP can be silent on exactly how this trade benefit–cost tradeoff will be done, but this silence may increase the probability of a protest. In this case, the lack of instructions was misleading, for the standard was stated in threshold form with no indication that capability above that threshold would be traded against capabilities in other areas (i.e., explanation of the SSEB conditional decision rule for trading off capability above this threshold).

**Benefits traceable to evaluation factors.** In the USAF Desktop IV case in May 1993, it was stated that the evaluator cannot assign benefit to services or capabilities (including using them as discriminators in Best Value) not specified somewhere in the RFP (O'Keefe, 1993). The services must be requested or identified in some useful language in the RFP. Note that the same ruling established that services that are inherent but unstated can be used and assigned a value (Federal Acquisition Report, 1993). The Desktop IV ruling also established that the National Defense Authorization Act of 1991 gives defense agencies the authority to make Best Value awards without discussions with offerors—again no change from established practice (O'Keefe, 1993).

**Burden of proof for compliance with solicitation terms.** In a recent and important decision, the GSBCA upheld a protest by the B3H Corporation against the U.S. Air Force (GSBCA No. 12813-P-R, 1994 GSBCA LEXIS 255 ) on the basis that the Air Force made the award contrary to the terms of the solicitation, indicating that the record does not "with any degree of certainty" support the conclusion that the added values of the awardees' proposals were worth the higher prices associated with those respective proposals. The protest was by a small business that protested only the small business award of a multiple-award procurement, contending that the protester had the lowest cost of the small business proposals, and that the Air Force selection process was inconsistent with the terms of the solicitation. It was claimed that the Air Force did not show that the proposals of the two small business offerors awarded contracts were worth the extra 15 percent and 5 percent costs respectively associated with them. Thus the B3H Corp. maintained that its proposal represented the best value to the government. The decision of the GSBCA supported this contention, indicating, among other things, the following: "What is lacking as a whole is a reasoned basis leading to the conclusion that the benefits of the awardees' proposals are in fact worth the apparent extra costs."

The single dissenting judge (one of three) to the GSBCA decision summarized his view of the implication of the GSBCA decision to uphold the protest. "There is also the matter that the majority seems to think that the Air Force, when challenged, is required to prove that its procurement is perfect. In every legal system of which I am aware, quasi or otherwise, he who alleges an impropriety must produce evidence sufficient to prove it. This majority, for whatever reason, has reversed that fundamental rule. In this procurement, the protester said it didn't think the two better qualified offerors were worth the additional money, but it offered no evidence at all to prove it, thus committing the same sin that the majority says that the government committed, and which the majority used as a reason to grant the protest."

**"In every legal system of which I am aware, quasi or otherwise, he who alleges an impropriety must produce evidence sufficient to prove it."**

In Widnall *v.* B3H Corp. (1996), the B3H decision was overturned by the U.S. Circuit Court of Appeals, which stated that if the GSBCA board task is to assure that an agency's procurement decision is

grounded in reason, and if such is the case, then the board defers to the agency decision, even if the board might have chosen a different offeror (i.e., there is not necessarily a need to be right, only to be reasonable). The court further noted that discriminators can be quantified or non-quantified "for the board does not require that each difference in a proposal be assigned an exact dollar value representing its worth to the government." (Widnall *v.* B3H, 1996, part III). The agency is required to present a reasoned analysis showing that the government expects to receive benefits commensurate with the extra costs it will have to pay. This case also goes on to describe other decisions entrusted to the agency and thus the SSA including, for example, which nonquantified discriminator to emphasize. Thus, this decision removes the apparent need for the agency to prove that its analysis is "correct" beyond some reasonable doubt.

**"The question seems to regard what constitutes sufficient rigor with respect to establishing the relative worth of any benefits claimed for an offeror who is not the lowest bidder."**

### Implications of Best Value Protest Findings

There are several implications of these findings, and unfortunately they are not unambiguous. One is that there has not been agreement on what constitutes sufficient demonstration of Best Value. It is very obvious that no one is asking for a "perfect" analysis, as was clearly demonstrated in the TMAC II decision. However, as demonstrated clearly by B3H, some systematic demonstration of the benefit to cost tradeoffs beyond a mere statement of opinion by the SSA is required. Even the dissenting judge in the B3H protest would probably not argue with this. The question seems to regard what constitutes sufficient rigor with respect to establishing the relative worth of any benefits claimed for an offeror who is not the lowest bidder. Systematic dollar value quantification of impact area benefits using rigorous quantification procedures and measures based on historical precedent will likely provide sufficient proof. However, it is generally not clear what parts of benefit can be translated to dollars. The B3H decision demonstrated that the SSA's detailed claims regarding increased savings to accrue may not be sufficient (at least to some judges). But Widnall *v.* B3H demonstrates that a "reasoned analysis" is sufficient. Would a sufficient justification be a systematic, linked tradeoff process such as that used in the Multi-Attribute Utility Theory (MAUT) technique with a judgmental assessment of the benefit-to-cost link supported by logic and rationale? This is more systematic than extensive testimony by the SSA in B3H, but it is less rigorous than detailed cost modeling of the increased benefits using precedent-based measures. This question is not clearly answered by these cases, but this is certainly a reasoned analysis that satisfies the criteria of Widnall *v.* B3H.

Another finding that is apparent from these cases is that the government should be very clear in its guidance to offerors, specifying in advance the procedures it intends to follow and even its conditional decision rules where feasible. The government should specify not only that a Best Value procurement will take place, but that

cost and technical factors will be traded off. An example in support of this prescript is the U.S. Marine Corps Mobile Protected Weapon System (MPWS) procurement. In that concept design procurement the government provided the offerors the actual evaluation structure, in that case a MAUT model, including the attributes (called factors or criteria) and intra-attribute utility functions, attribute weights and rationale for all. The evaluation was quite successful (see Buede & Bresnick, 1992).

The government should obviously follow the procedures specified in the SSEP and explained to offerors in the solicitation and should avoid any procedures not so specified. But the government cannot specify all possible contingencies. Further, it cannot specify the exact details that will determine a decision outcome. It can clearly define the evaluation factors and subfactors (if any) and specify how the evaluations will be conducted with respect to these. The specific Best Value methodological approach to be used can be clearly laid out in the solicitation. In current practice, however, there is not apparent agreement on a single recommended approach. An urgent job for decision analysts is, at a minimum, to lay out guidelines for several conditional approaches along with the conditions under which each approach should be employed. Unless this is done, the solution may well be determined by legal experts having only a partial understanding of the measurement concepts and resultant implications of their decisions.

The thing that is unclear from the legal discussion is the specific nature of the benefit-to-cost tradeoff. The B3H case demonstrates that a mere verbal description of benefits by the SSA is probably not sufficient justification for decisions. Other protest outcomes (e.g., Widnall *v.* B3H) seem to demonstrate that an attempt at a systematic approach to characterize benefits and offeror differences with respect to discriminator impacts should suffice. The use of MAUT tools to aid the SSAC in this systematic tradeoff process should be valuable. Such a MAUT approach would be hardest to defend if it relied only on judgmental assessments. These judgmental assessments should be systematically linked by the MAUT process and supported by rationale, and thus they would be better than SSA opinions about the group of discriminators (the apparent problem in B3H).

If the benefit tradeoffs were further supported by a linkage to cost realism estimates through a systematic analysis or algorithm, the MAUT analysis would be very strong and should provide the "reasoned analysis" required by the GSBCA. The MAUT analysis will generally not take as much time as a detailed costing of discriminator impact areas using rigorous costing algorithms. The SSAC and BVWG generally do not plan to spend several weeks or months doing the Best Value analysis. This would imply that costing, if done, would involve simplified approximations to more formal approaches. Otherwise, MAUT provides a reasoned analysis that can be accomplished in a shorter time.

**"An urgent job for decision analysts is, at a minimum, to lay out guidelines for several conditional approaches along with the conditions under which each approach should be employed."**

One answer to the desirable nature of the benefit-to-cost tradeoff process is, "It

depends." That is, sometimes tradeoffs can be quantified; sometimes they cannot. Measurement always involves abstraction of the real world situation to a mathematical model, and the models appropriate for different conditions are different. The lack of a universal answer may be dissatisfying to some, but it should comfort the practitioners who have always shied away from quantification because they feared rigid application of inappropriate models. It should also satisfy the practitioners who wish to plan ahead, for it implies that the entire acquisition must be systematically implemented, with linked modeling and measurement procedures defined early and consistently implemented. This can help prepare for later quantification of benefits.

A general summary of this guidance is that when the source selection is done, the source selection team must be able to convincingly show that the analysis and decision-making process were sound and fair. An SSA opinion that "the added cost is worth it" will probably not suffice (and did not initially in the referenced B3H case). All costs and benefits must be systematically characterized as quantified or not, and the decision process must have a systematic, understandable, and consistent logic thread. Unquantified benefits can be traded against cost differences, but the trades must be rigorous, understandable, and the result of a "reasoned analysis," a logically consistent decision process. While there may be some residual uncertainty about the absolute precision of assessments used in evaluations, the procedures were applied to all offerors in an evenhanded manner.

Decision support tools help to provide the necessary consistency and audit trail. The use of these tools provides for public scrutiny of the evaluation process and avoids an inherent weakness in the argument of the dissenting judge in the B3H protest case. That judge seemed to claim that the SSAC shouldn't be second guessed because the board is most knowledgeable on all the issues and thus best qualified to make the tradeoff assessments.

However, while the SSAC members may be quite knowledgeable, this doesn't guarantee the sanctity or even the correctness of their procedures. An "analysis based in reason is still required." (See O'Connor, Faris, and Lovelace [1996] for further discussion of such analyses and tools to support them.)

## Recommendations Based on Best Value Applications

The authors have collectively applied the principles, procedures, and tools discussed in this article to more than 100 acquisitions, many of which have involved Best Value source selections. This section provides recommendations resulting from that Best Value work.

### Time: Underestimation and Resultant Rush to Judgment

All of the historic problems of planning time pertain to acquisitions. More often than not, the evaluation team develops an evaluation schedule (and program schedule) based on overly optimistic estimates of the time needed to accomplish the activities involved in executing the source selection plan. The reasons are many and are well known to practitioners. For example, the time required for the Source

Selection Evaluation Board to accomplish its evaluation is very often longer than planned. The time required for discussions with offerors including clarification requests, deficiency ratings, oral discussions, and revision of offers is also very often longer than anticipated. Yet, because acquisitions are usually highly visible to the government and public, and delays in awards can be costly to all, the planned award announcement date is maintained until it is obviously impossible to attain. Usually, rather than slip that date, the time allowed for activities at the end of the cycle are squeezed. In Best Value source selections, this squeezed time is the time for the Best Value working group to accomplish Best Value deliberations and discriminator quantification. This problem is often further exacerbated by insufficient time allotment to these activities (especially discriminator quantification) in the original schedule. This insufficiency in the original scheduling can be caused by a lack of understanding of both what is involved in Best Value source selections and of the time required to implement a valid cost–benefit tradeoff process and associated discriminator impact benefit quantifications.

The validity and precision of the cost–benefit tradeoff process and associated discriminator impact benefit quantification are directly affected by the time allotted to them. Procedures to assure validity, precision, and thus "correctness" take time. The recommendation here is obvious. Sufficient time should be allotted to the Best Value deliberations in the original source selection schedule, and that time should not be shortened unless it becomes clear that it is not required, (e.g., a Best Value situation does not eventuate after SSEB evaluation). As a general rule, at least one month should be allotted to discriminator impact benefit quantification.

The authors have often faced the argument that there is no need for benefit quantification, especially if it is going to be done poorly, and that traditional source selection procedures will suffice. The benefits of the Best Value approach will not be argued here, save to note that it was originally developed to address an apparent inadequacy in the traditional process. The issue that the traditional process should be implemented because practitioners do not plan and implement well is not really a viable one. If the intent to use a Best Value process has been stated to the offerors, then it should be implemented as well as can be done.

**"Sufficient time should be allotted to the Best Value deliberations in the original source selection schedule, and that time should not be shortened unless it becomes clear that it is not required."**

## Clarity of Intent to Use a Best Value Process

Another important issue is that it should be clear both to offerors and the acquisition team that a Best Value process will be used. Vague wording such as "the government will choose the offeror providing the best overall value to the government" are considered by some practitioners to adequately signal a Best Value acquisition to the offerors. For the offerors, a less ambiguous statement is one that indicates that the government will implement a Best Value process that will involve

a cost–benefit tradeoff process. For the government, the SSAC members should understand the Best Value process that will be used and should plan accordingly for it.

### Best Value Working Group Composition and Procedure

A BVWG chairperson should be appointed as early in the evaluation process as feasible. This provides time for that person to organize for such issues as BVWG composition, schedule, and procedures as well as to begin to attack technical issues such as procedures and tools for cost–benefit tradeoffs and discriminator impact benefit quantification. The BVWG should include a sufficient number of SSAC personnel to assure valid benefit assessments and also SSAC buy-in into the analysis results. At the same time, the BVWG should not be so large that meetings are too large and progress difficult. All BVWG members should expect to be workers that will participate totally in the Best Value cost–benefit tradeoff process. The larger this group, the more important it is that the meeting leader (BVWG chairperson or a facilitator) possess both good meeting facilitation and analysis skills.

**"A set of discriminators must be established that validly characterizes the benefit advantages of each of the proposals over others."**

The BVWG should also include evaluation personnel most familiar with the content and evaluation of the offerors' proposals. This familiarity includes knowledge of the basis for assessed costs and assessed technical and management benefits associated with the respective proposals. Such personnel include Source Selection Evaluation Board (SSEB) members such as the technical, management, past performance, and cost panel chairpersons. These personnel can serve as BVWG advisors.

### Discriminators: How Many?

The number of discriminators needed is often pondered. The answer depends on the particular source selection and will evolve from the proposal evaluation process and results. A set of discriminators must be established that validly characterizes the benefit advantages of each of the proposals over others. The discriminators must not necessarily span all of the benefits, but rather must characterize the benefits that discriminate in a discernible way among proposals. Thus benefits common to all need not be reexamined at this point.

All discriminators must be traceable back to one or more evaluation factors. This doesn't mean that they correspond to a specific set of evaluation score differences, but they must be inherent in the intent of the evaluation or must be derivable as implications of the evaluation. (No new evaluation factors representing services or capabilities not requested in the solicitation should be introduced at this point. This is an important and often difficult issue that can be misunderstood.) Discriminator impact areas must be identifiable and clearly stated, for it is these to which benefit is attached. If this linkage cannot be established, the discriminator should be reexamined. These are issues relating to cost–benefit analysis procedure, and they will not be discussed in detail here. The principles and procedures employed in decision analysis, especially

those of Multi-Attribute Utility Analysis (usually denoted as MAUA, MAUT, or MAU), are particularly relevant here.

### Treatment of Risk

The risks associated with offeror proposals are treated to a degree in the cost-realism adjustments described in the first report in this three-article series. The most probable cost to the government (MPC) thus incorporates some of the proposal risk implications. However, as indicated in the first report in this series, certain discriminators will also involve risks. Avoidance of risks associated with one offeror can be a benefit or advantage associated with choosing another offeror's approach. Thus analytic procedures for quantifying risks associated with offeror proposals are very relevant. These will not be discussed here, but it is quite important that BVWG members understand and can employ these procedures or can get assistance in doing so.

One should also note that the term "risk" has multiple meanings and can be a source of confusion. For example, some government agencies have SSEB (or an equivalent body) members evaluate offeror proposals by assigning each factor a rating and a risk.

Still others assign factor ratings at one level and risks at the next higher level where the several factor ratings are aggregated into a single rating. Usually the factor ratings are pegged to an evaluation scale or standard. The risks, if defined, are usually briefly described. These do not represent the kind of risks often discussed in economic or decision analyses. Yet they do represent the consensus of an evaluation panel regarding a conditional evaluation of an aspect of an offeror's proposal. Recall that it is not these risks that would be directly quantified, but rather the judged impacts of the risks. Clearly the impact must be carefully characterized, and the approach to such characterization must be consistent throughout the analysis. The BVWG should carefully plan for this difficult process. The goal is not for a perfect analysis, but it is to achieve a consistent, "reasoned" analysis.

## REFERENCES


Best value procurement: ITAA urges changes in best-value process. (1993, December). Federal Contracts Report, 60, p. 574.

Buede, D. M., & Bresnick, T. A. (1992, June 22). Application of decision analysis to the military systems acquisition process. Interfaces, pp. 110–125.

Carroll, T. P. (1994, May). Cost realism. Contract Management, pp. 21–23.

Faris, J. L., & Lovelace, J. S. (1995, June). A methodology for estimating best value. Proceedings of the 1995 Acquisition Research Symposium, sponsored by the Deputy Under Secretary of Defense for Acquisition Reform.

Federal acquisition regulation. (as of Jan.1, 1993). Commerce Clearing House Business Law Staff Publication. Chicago: Commerce Clearing House.

Federal acquisition report. (1993, August). Page 5.

GAO Review (Brunswick Defense). (1994, April). Federal contracts report, 61, pp. 576–577.

General Services Administration Board of Contract Appeals. (1994, Aug. 2). GSBCA No. 12813-P-R, 1994 GSBCA LEXIS 255.

Grumman Data Systems *v.* Department of the Air Force, GSBCA No. 11635-P, 1992 B.P.D. § 100.

Koch, D. S. (1994, May). Procurement: Disclose the price/technical tradeoff. Contract Management, pp. 11–16.

Krantz, D. H., Luce, D., Suppes, P., and Tversky, A., The foundations of measurement, Vol. I, New York: Academic Press, 1971.

Lockheed Missiles and Space Company *v.* the Department of the Treasury, GSBCA Nos. 11776-P, 11777-P, 1992, B.P.D. § 155.

O'Connor, M. F., Faris, J. L., & Lovelace, J. S. (1996, January). Decision support in "best value" source selections (Tech. Rep. MTR 96W0000001). McLean, VA: The MITRE Corporation.

O'Keefe, S. W. T. (1993, February). Desktop IV: An indictment of fast track awards. Government Executive, pp. 42–44 (September 1978).

Proposed evaluation-cost/technical tradeoffs. (1994). Federal contract report, 61, pp. 511–513 (00149063/94).

Sochon, G. M. (1994, May). Greatest value source selection—Making it work. Contract Management, pp. 21–30.

Systems Resourses Incorporated *v.* Department of the Air Force, GSBCA No. 12536-P, 1993, B.P.D. § 253.

USGSA Information Resources Management Service. (1992). Source selection: Greatest value approach (Report, V, Document #KMP-92-5-P). Washington, DC: Author.

*Widnall v. B3H Corp*, 75 F.3d 1577; 1996 U.S. App Lexis 1843; 40 Cont. Cas Fed.

## ENDNOTE

1. In one version of this approach, benefits are characterized as "quantifiable" and "nonquantifiable", and the described tradeoff process is accomplished for the "quantifiable" benefits. The "nonquantifiable" or "qualified" benefits can only be used as tie-breakers. However, the distinction between "quantified" and "nonquantified" benefits in any of the Best Value implementations is not clearly defined. In fact, whether a benefit can be quantified may be a function of the degree of planning for such tradeoffs done early in the acquisition process. The term "quantification" can lead to confusion between the ability to quantify and the nature of the scale or "uniqueness" of the measurements obtained from the quantification procedure (Krantz, et. al., 1971).

# COST AS AN INDEPENDENT VARIABLE: *CONCEPTS AND RISKS*

**Dr. Benjamin C. Rush**

Cost as an Independent Variable (CAIV), implemented in early 1996, is a new initiative to reduce defense system costs. Here we'll look at the definitions, concepts, processes, and risks of CAIV, with examples from the eight flagship programs that are leading in its use.

In the past decade of tremendous changes in defense systems acquisition, the most significant factor is the dramatic drop in dollars available to buy new systems. This mandates new thinking on strategies and processes for acquisition. Part of this change in thinking is Cost as an Independent Variable (CAIV), a new initiative to reduce life-cycle costs of defense systems. CAIV was proposed in 1995 and implemented in March 1996 as a part of the new 5000 Series regulations on defense systems acquisition (DoD 5000.2R, 1996). Compliance with the principles of CAIV is required for all acquisition category (ACAT) I and IA programs and, at the discretion of the component acquisition executive (CAE), the principles may be applied to other programs. Implementation of CAIV is basically in two steps: first, when a mission needs statement (MNS) is approved (and the concept exploration phase begins), an approach is laid out to set cost objectives; and, second, upon program initiation (usually at Milestone I approval), the actual life-cycle cost objectives are established by the program office.

Two Department of Defense (DoD) working groups led the definition and implementation of CAIV. A Defense Manufacturing Council working group developed a CAIV working group report disseminated in December 1995 which describes a strategy for setting aggressive, realistic cost objectives for acquiring defense systems and managing the associated risks. In June 1996, the Flagship Programs Workshops began meeting under the leadership of Dr. Spiros Pallas of the Office of the Secretary of Defense (OSD). The participants include representatives of eight defense programs, as well as representatives of OSD, the Institute for Defense Analyses (IDA) and the Defense Systems Management College (DSMC). Table 1 lists the eight flagship programs as well as their current program phase and

a short description of the weapon system. Flagship programs are sharing problems and solutions in implementing CAIV policy.

## DEFINITION

CAIV is a new DoD strategy that makes total life-cycle cost as projected within the new acquisition environment a key driver of system requirements, performance characteristics, and schedules. This is a 180-degree conceptual change in thinking from the days of requirement-, performance-, and sometimes schedule-driven costs. While the life-cycle cost–performance–requirements tradeoff process is the heart of CAIV, a broader definition is necessary to recognize the environment in which these trades take place. Programs are being aggressively managed to meet program objectives concomitantly with the implementation of reform initiatives such as: use of commercial specifications and practices; use of integrated product and process development teams; and contractor enterprise reengineering. Acquisition reform initiatives have the potential to significantly reduce cost and change the baseline against which cost–performance–requirements trades are benchmarked. The Defense Acquisition Deskbook provides a description of CAIV within this broader context: "CAIV is a strategy that entails setting aggressive yet realistic cost objectives when defining operational requirements, acquiring defense systems, and managing achievement of these objectives. Cost objectives must balance mission needs with projected out-year resources, taking into account existing technology, maturation of new technologies, and anticipated process improvements in both DoD and industry" (DoD, 1996). In some ways CAIV suffers from the combination of too many initiatives to be easily explained. Philosophically CAIV is the combination of all the best practices affecting cost.

## CONCEPTS

The implementation of CAIV requires new thinking about program management. If cost is truly the key driver of performance and schedule, no single cost reduction strategy is likely to be sufficient. All cost reduction initiatives must be considered. In a presentation by the Institute for Defense Analyses at the Flagship Workshop in July 1996 (Bell, 1996), a hierarchy of CAIV cost levers was proposed. All of these levers are important in CAIV implementation. They are listed in rough order of potential benefit for most programs:

**Dr. Benjamin C. Rush** is a professor emeritus at the Defense Systems Management College. He received his doctorate from the University of Southern California in the Graduate School of Business Administration. He has over 30 years of financial and program management experience in the Department of Defense and defense industry.

| PROGRAM | PROGRAM DESCRIPTION | PROGRAM STATUS |
|---|---|---|
| EELV | A more cost-effective space launch vehicle for medium and heavy lift requirements | Pre-EMD start Dec. 1996 |
| AIM-9X | Next generation Sidewinder air-to-air missile | EMD start Jan. 1997 |
| TACMS-BAT P3I | Upgrade of tactical ground-to-ground missile - new seeker | Currently in PDRR<br>EMD start in 1998 |
| MIDS | Third generation secure, jam-resistant, communications system for NATO family | EMD contract awarded in Mar 1994<br>Restructured Jun. 1994<br>CDR in-process |
| JASSM | Long-range air-to-surface standoff missile | Entered 2-year competitive PDRR |
| CRUSADER | 155MM self-propelled Howitzer and armored resupply vehicle | Completion of PDRR in FY 2000<br>Single contractor team |
| JSF | Advanced Strike Fighter Aircraft | Pre-PDRR |
| SBIRS | Space-based infrared surveillance system for missile defense | Entered EMD for GEO in FY 1996<br>PDRR for LEO with MS II in FY 1999 |

**Table 1. CAIV Flagship Programs**

1. Requirements–cost–performance trades. This is the essence of CAIV and is discussed in detail in following sections.

2. Acquisition strategy. Competition is the greatest lever that the government has in the early stages of a program to ensure that CAIV objectives are met. Because of this, competition should be maintained as long as economically practical.

3. Concurrent engineering/integrated product and process development (IPPD). To meet an aggressive cost target, team members must cooperate to ensure that all functional planning be integrated and that difficulties are discovered and resolved early on.

4. Contractor enterprise reengineering. The lean enterprise philosophy encourages industry to concentrate on core capabilities and to develop

long-term relationships with key suppliers for non-core activities. It also requires that core activities be conducted with maximum efficiency.

5. Commercial specifications, practices, and components. Acquisition reform has enabled use of commercial specifications and practices in many areas. The use of commercial components, where technically feasible, is an important cost reduction tool for many programs.

DoD expects cost savings from these cost levers to enable 50 percent and greater reductions in cost from the old way of doing business. The Joint Direct Attack Munitions Program is a frequently cited example of a program that is achieving this magnitude of reduction from the broad impact of the new way of doing business.

The preceding consistently addresses the tradeoff process as cost–performance and requirements. This emphasizes the role of the user and the importance of the transition from the requirements process to contracting for system performance goals. The process considers the changing nature of requirements as system development progresses. To enhance the effectiveness of CAIV, programs minimize the number of system performance parameters stated in the Operational Requirements Document (ORD) at Milestone (MS) I. This allows performance objectives to be developed that are achievable and affordable based on actual development and additional analysis during Program Definition and Risk Reduction (PDRR). If the number of key performance parameters are kept to a minimum while continuing to meet the user's real needs, greater leeway is provided for future tradeoffs. The system performance parameters called out in the ORD are designated key performance parameters and are not tradable below a threshold value. Thus for key performance parameters the only trade space is between threshold and objective values. Both values are stated in the ORD and in the Acquisition Program Baseline (APB), and using the CAIV strategy are refined until MS II.

**"To some extent, previous attempts at cost–performance trades fell victim to inflexible requirements from the user or overspecified requirements by the acquirer."**

For technical performance parameters, the CAIV targets should be the same as those in the APB. For CAIV cost threshold and objective values, there are potential problems with having them equivalent to the APB values. The program budget cannot exceed the APB cost threshold and the cost threshold is specified as 10 percent above the objective value (5000.2R, Part 3.2.1 and 3.2.2.2). This may provide little cost room to solve technical performance parameter breaches.

To some extent, previous attempts at cost–performance trades fell victim to inflexible requirements from the user or overspecified requirements by the acquirer. Performance goals have frequently been driven by available technology where the contractor and program management office (PMO) strive for "the last ounce of performance." The threshold and objective values for key performance parameters are initially developed as the user translates the broadly stated

mission need from the mission area analysis into a system description for the ORD. An analysis of alternative system concepts should focus on determining the appropriate technical performance trades prior to the initial ORD and APB at Milestone I. The key performance parameters are stated in the initial ORD and APB and updated at each milestone. For effective contracting, performance must be stated as overall system performance goals rather than as detailed specific performance parameters. Changing these goals during system development because of changing mission requirements from the user will greatly hinder the CAIV process. Further, the user and acquirer must be willing to accept lesser performance for less cost within the trade space. Changing the culture regarding lesser but acceptable performance is critical to successful implementation of CAIV. Thus, the user must be an integral player throughout the process as the cost–performance–requirements tradeoffs are made in each phase of the life cycle.

Clearly the tradeoff process is more effective if it can be accomplished earlier in the design process. A large percentage of the cost is determined by a small percentage of the design decisions. These critical cost-driving design decisions normally are made very early in the concept selection and design process. Because of this, expect greater success in implementing CAIV for programs in concept exploration or program definition and risk reduction phases. There are significant problems estimating production and operations and support (O&S) costs early in development but these estimates can be updated and improved over the product's life cycle. Improved estimates will have the greatest program impact if competition continues.

How is this different from design-to-cost (DTC)? This question is frequently asked in discussions on CAIV. CAIV embodies more than the tradeoff process that is DTC and there are key conceptual differences. Under CAIV, the user is an active participant in the tradeoff process throughout the life cycle. This is not normally the case with DTC. Another key difference is CAIV's more flexible requirement based on threshold mission effectiveness. Earlier planning in the life cycle by the user and acquirer with an iterative refining of the objectives is another difference. In the past, DTC has been predominantly a contractor's process, executed during the system design. In the simplest terms, consider DTC as one of the tools for the implementation of the CAIV concept.

## PROCESSES

The DoD initiative on IPPD and integrated product teams (IPTs) is central to the implementation of CAIV. Within both contractor and government organizations, it is expected that this initiative will have been implemented. Under the direction of the government program manager (PM), a cost–performance IPT (CPIPT) will establish the program cost objectives and facilitate the cost–performance–requirements tradeoff process. Team membership includes the user from the outset, and contractor representation as it is determined appropriate (as per 5000.2R, Part 1, Section 1.6). Other members vary depending on the phase of the life cycle but could include the service cost center and

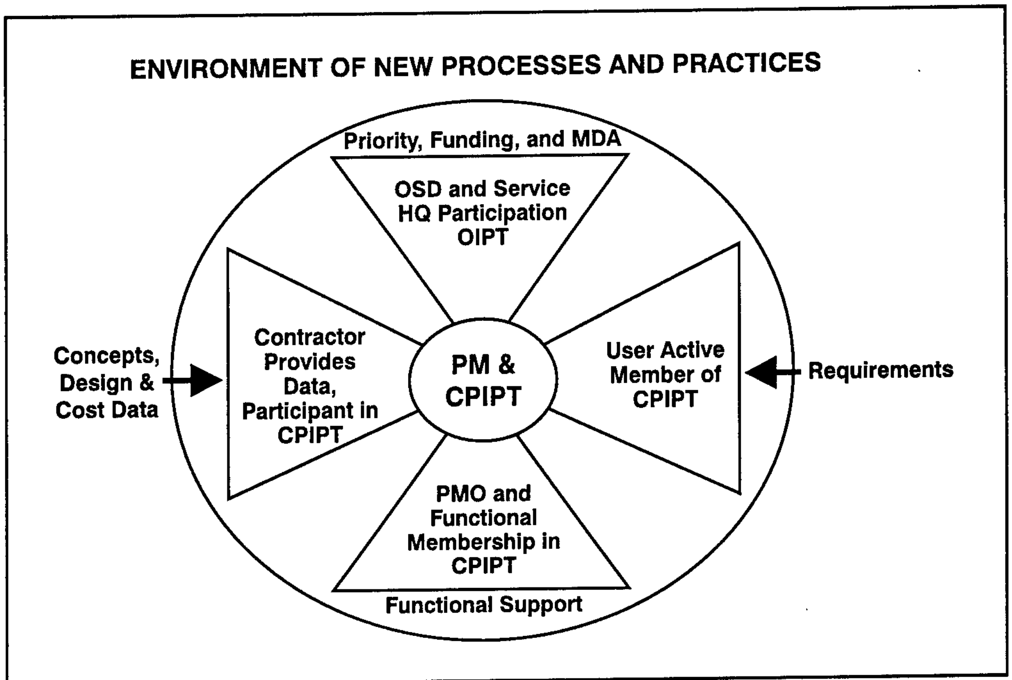



**Figure 1. Participants in the CAIV Process**

the OSD Cost Analysis Improvement Group (CAIG) as does the Joint Air-to-Surface Standoff Missle (JASSM) program. A detailed discussion of the membership and roles of the CPIPT is provided in the "Life Cycle Cost-Performance Concept Paper" (DoD, 1995).

The CAIV process is an iterative one focused on the PM and CPIPT (Figure 1). The PM and CPIPT work with the Overarching-IPT representing the program evaluation officer, service headquarters, and OSD in determining funding, receiving programmatic direction, and providing program status. The PM and CPIPT must have a strong working relationship with the user community in establishing cost-effective requirements and determining priority. The PM and CPIPT have a number of supporting acquisition organizations, from functional support within the component command to service cost centers, which provide cost estimates and analysis. Design and cost analysis by the contractors provide the CPIPT with the information necessary to analyze cost–performance tradeoffs. This circle of relationships around the PM and CPIPT enable a sequence of activities necessary to accomplish CAIV. These include the development of aggressive cost goals, implementation of incentives to encourage the accomplishment of these goals, and measurement of specific CAIV performance through tracking of metrics.

## Setting Aggressive Cost Targets

Developing aggressive cost goals requires the CPIPT to consider a number of elements, including available resources, costs of comparable systems and components, mission effectiveness studies, tech-

nology base trends, and the use of such initiatives as lean manufacturing and commercial business practices. The CPIPT must work to develop initial aggressive cost goals using these elements and the following framework.

1. Using affordability as the key criterion, the service headquarters divides a fixed budget among competing programs. Here the cost goals are used in developing budget required for that program and compared with the available dollars in the Program Objective Memorandum (POM) years based on the priority level established by the service, Joint Requirements Oversight Council (JROC), and others. This fixed budget based on the priority of the program is the reality of what is available for structuring the program. The current budget may be less constraining in the out years, but still drive the program acquisition strategy.

2. Using mission effectiveness as the key criteria, the user and service headquarters must determine "the most bang for the buck" of the proposed system. Here analytical studies begin with mission area analysis and analysis of alternatives and result in a set of requirements in a mission need statement and the ORD. This analysis would look at the proposed program in terms of mission effectiveness versus performance requirements and performance requirements versus cost. There are different DoD organizational elements involved in this analysis, depending on the service: Center for Naval Analyses (Navy), Training and Doctrine Command (TRADOC) (Army), combat command (Air Force), and Program Analysis and Evaluation (PA&E) (OSD). These studies provide the necessary tie between mission requirements, performance parameters, and the cost effectiveness required of the system.

3. The PMO would normally have access to independent research and contract studies by contractors, which provide concepts and cost estimates for achieving the required system performance requirements. These concepts and associated costs may vary widely from one study to the next but provide the critical contractor perspective on range of alternatives and provide key data to the above-mentioned analysis of alternatives and funding exercises.

The PM, through the CPIPT, must find a set of initial cost goals that provide an affordable budget and still enable the system to meet at least the threshold requirements of the user. If the cost goals include consideration of the most likely cost of the performance and schedule requirements, there can exist a legitimate trade space for cost–performance tradeoffs and the cost targets will be realistic. If initial realistic cost goals cannot be developed through this trade program within the budget affordability, the program is not viable. The initial cost goals will be refined at each stage of development to ensure a balance between the realistic and the aggressive. They will be referred to as cost

goals by Milestone I, as cost targets by Milestone II, and firm cost targets by Milestone III.

The key focus of CAIV is on the total life-cycle cost (LCC) of a program with LCC in four separate cost objectives: research, development, test, and evaluation (RDT&E); production; operations and support; and disposal. Here we give primary attention to the production cost objective and the operations and support cost objective reflecting the emphasis of the flagship programs.

The production cost objective is defined in several ways. The basic term associated with production costs of individual items of a program is known as "average procurement unit costs" (APUC). The APUC is calculated by dividing the total procurement cost by the total procurement quantity of the program. Also of interest to a PM is the average unit cost of those items contracted for in each production lot. The average unit production cost of a production lot will normally vary from one production lot to the next based on learning curve theory and other factors. Further, the production lot average unit values will be different from the APUC, which is based on the total program quantity. Additional confusion can occur when one compares production costs of different programs, because of different definitions. Examples from the JASSM and AIM-9X flagship programs are the inclusion in production costs of "bumper to bumper" warranty costs (although for differing periods). Other programs have no warranty costs in their average unit costs.

**"The implementation of incentives is a critical part of ensuring the necessary changes. These incentives can be either positive (achieving targets) or negative (failure to meet targets)."**

The second area of operations and support costs is even more difficult to predict. Contractually, operations and support costs may best be handled (as several of the flagship programs have done) by setting aggressive goals for key performance parameters that drive O&S costs, such as mean time between failure (MTBF) and mean time to repair (MTTR).

## Implementation of Incentives

The implementation of incentives is a critical part of ensuring the necessary changes. These incentives can be either positive (achieving targets) or negative (failure to meet targets). If the contractor is not meeting the program cost targets, an acquisition strategy could be structured to restart competition. An acquisition strategy guide provides the optimum level of competition by phase is one of the most effective ways to ensure cost is minimized. Flagship program examples are the JASSM and Evolved Expendable Launch Vehicle (EELV) programs, which use rolling down-selects (selecting fewer contractors for each succeeding phase) with the final development contract competition including low-rate initial production and the incentive of continuation in a sole-source mode as long as the final cost targets structured during the final competition are not breached.

In many programs, the quantity or other factors prevent the ability to have competition in production. In these situations, the use of award or incentive profit can play a major role. The Crusader program is an example of a program with a sole-source

contractor in development through procurement, where an award fee is being used to motivate contractor performance. This is in an environment of minimal mil-specs, mil-stds, and contract data requirements lists. The Space-Based Infrared Systems (SBIRS) program uses an incentive fee to share the cost savings between the government and the contractor. An important motivator for all programs is the shared decision role through contractor participation on the CPIPT.

Another element is providing appropriate incentives to the government employees who make major contributions to the success of the program. This has been tried with mixed success. One of the major difficulties is that monetary awards are not allowed for military members of the government team, but a change in the law is under study.

### Measuring Performance Through Tracking of Metrics

There is a need for validated cost models to track life-cycle cost during program execution. The government should have access to contractors' models and methodology. This does not mean that the government and contractor have the same models, but they work together to share and validate. The contractor's design-to-cost system must provide a flow-down of the APUC to the engineering design level with status reporting, corrective actions, and trend analysis. The reporting process is incorporated into the contract statement of work. The Crusader program showed that the models used for trades were inadequate for cost tracking. The AIM-9X program demonstrated that it was extremely valuable to establish early a government–contractor APUC working group. An APUC baseline can later be altered to account for government-directed design changes, quantity changes, and economic price adjustments. Any change in the baseline must be directly traceable so that the cause and magnitude are documented.

The operations and support costs tracking process has been handled by the flagship programs in one of two ways. Where the contractor has provided a warranty as part of the APUC, the government need only be concerned with the cost models at the time of warranty negotiation. When there is no warranty, the government interest shifts to the impact of the technical cost drivers. The system O&S costs are best controlled through test and analysis of the technical parameters driving O&S costs such MTBF and MTTR. Technical performance measurement should be used to track all critical performance parameters including those driving O&S costs.

## Risk Management in CAIV

The areas of risk listed below must be addressed as a part of the CAIV process. Some of these risks are in conflict with others; they must be continually balanced. The process is an iterative one and the risks come into play multiple times during the life of the program. Among the key areas that CAIV must consider are:

1. Risks that the current budget and priority decisions for a system are sufficiently accurate and remain stable over the program life cycle to provide realistic system affordability.

The program budget must be realistic and stable for a successful program. This is a major problem in managing most acquisition programs; it will be even more critical under CAIV, where cost explicitly drives performance and schedule.

2. Risks that the threshold performance requirements will provide the necessary mission effectiveness and will be stable during system development and production, and risks that the difference between threshold and objective requirements will provide sufficient trade space to allow tradeoffs between cost, schedule, and performance.

   The balance between ensuring that the system will meet the user's true requirements and the necessity of the threshold requirement being sufficiently low that real trade space exists between the threshold and objective is critical to the tradeoff process.

3. Risks that the shape of the function between performance, requirements, mission effectiveness, and cost can be determined and utilized in tradeoff analysis.

   The determination of this function and the desire to find the "knee of the curve" will require not only good cost data but extensive modeling of mission effectiveness. An excellent example is the work of the Joint Strike Fighter program in modeling these relationships.

4. Risks that the historical database for parametric estimates used in cost effectiveness assessment is sufficiently applicable to the system being estimated to provide an accurate most likely value and range (or probability distribution function) for the costs of the system.

   The database for parametric estimates always seems populated with programs that are sufficiently different in technology, design, or mission from your program so as to call into question the validity of the estimate. To achieve good tradeoffs, one must have good cost models with valid data reflecting the current acquisition reform initiatives.

5. Risks that the interrelationships of the system performance requirements are sufficiently understood to select the most cost-effective system performance objectives, and risks that the performance requirements are accurately translated to system performance contractual goals, which the contractor has sufficient incentive to achieve.

   The system performance goals are seldom independent. Understanding these interrelationships is critical to contracting with and providing incentive to the contractor.

6. Risks that the contractor DTC analyses accurately direct the system performance objectives to specific design and process decisions, and risks that the contractor detail

engineering (bottoms-up) cost data at the design level is sufficiently accurate to make the most cost effective design trades.

Does the contractor have a good DTC process? Without one, achievement of aggressive cost targets is unlikely.

7. Risks that technology developments will enable the achievement of specific design and process goals.

   If the performance requirements are too ambitious and can't be achieved, the cost and schedule of technology development will become the drivers.

   The central feature of CAIV is the tradeoff process; determining affordable performance and scheduling based on cost goals is accomplished by a set of decisions that balance the above risks.

## SUMMARY

The flagship programs will demonstrate the ability of the CAIV concept to achieve significant savings. Results will not be available for some time. In the meantime, all major defense acquisition programs in the first two phases of the life cycle are charged with implementing this concept and were required to submit a paper on CAIV implementation by July 1, 1996. These programs continue to report progress on this concept annually to their Milestone Decision Authority. We hope this and other articles on the implementation progress of CAIV will increase understanding of the concepts and, by so doing, further its ability to succeed as a key strategy in the management of all defense system acquisitions.

## References


Bell, G. (1996, July 11). Institute for Defense Analyses presentation to Flagship Programs Workshop.

Department of Defense. (1996, March 15). DoD Regulation 5000.2-R, Part 3.

Department of Defense. (1995, December 4). Reducing life cycle costs for new and fielded systems. CAIV Working Group Report distributed by memo from the Under Secretary of Defense.

Department of Defense. (1996, December 31). Defense acquisition deskbook (Version 1.3, CAIV description).

Department of Defense. (1995, July 19). Life cycle cost–performance concept paper. Distributed by memo from the Under Secretary of Defense.



AUTHOR'S NOTE

The author has participated on the CAIV Flagship Programs Workshops and is indebted to all the participants for the knowledge and insight provided by them during these sessions. The author would also like to acknowledge the contributions in reviewing this article by members of IDA and DSMC. Any errors are the responsibility of the author.

# A REVIEW OF THE LITERATURE: *COMPETITION VERSUS SOLE-SOURCE PROCUREMENTS*

***William N. Washington***

Competitive procurements often do achieve some savings over sole-source procurements, but a review of the literature analyzing this issue shows that the choice is not always straightforward. The savings is not always substantial, or is diminished by other costs associated with competition.

On what criteria should the decision to pursue competitive or sole-source procurement be based? A review of the literature brings several points to the fore. First, there is some rationale for supporting competitive over sole-source procurements, but not all competitive procurements produce savings; and the savings associated with going competitive are far less than the 25 percent cited by former Secretary of Defense Robert S. McNamara. Next, several factors should be considered prior to a decision to go competitive, such as production quantity, complexity of the item, capacity utilization of the industry involved, special skills, and sufficient data on the item. In addition, a cost–benefit analysis should probably be performed to determine the possible savings as a result of competition. Further, low dollar value spare parts, required in considerable quantity, or component parts and systems that are jointly used extensively by private industry, would seem to be the best places to implement competitive procurements.

## OLDER STUDIES ON THE BENEFITS OF COMPETITION

The previous research work in this area has seemed to follow a sequence, from more-or-less brief, rapidly compiled studies to more detailed and objective research over time. I thus reviewed the literature with the thought not only to compare the contract vehicles, but to consider the evolution of the studies, placing more weight on the later study efforts. To begin with, the early studies were generally based upon limited sample sizes, and dealt primarily with small systems or electronic components. These studies generally found consistent cost savings associated with competition programs, but in most

instances failed to take into account all the costs associated with the competition process, such as the cost of conducting the competition, setup costs for the new contractor, special tooling and government-furnished equipment, and the time value of money to set up the new contractor. A brief discussion of these studies follows.

Carter (1974) proposed that the Air Force try "directed licensing," where the original contractor, during the development phase, agrees to provide rights in the data, and to an agreement to license to whomever the government designates to produce the weapon system during any or all production runs following initial production. Carter felt this procedure would save money by forcing competition. He stated that previous contracting studies showed a 25 percent reduction in cost due to competition.

Olson, Cunningham, and Wilkins (1974) discovered that the cost savings associated with competition of spare parts ranged from 10 to 17 percent, with the most likely savings being 12 percent. They were cognizant of competition costs, but felt that for spare parts competitions, they generally would be negligible.

In a larger study, Zusman and Asher (1974) found that competition reduced costs by an average of 37 percent. However, as mentioned previously, they did not take into account the costs of conducting the competitions or their associated costs.

Lovett and Norton (1978) compared price behavior on 11 competitive contracts that previously had been sole source. They found cost savings from 0 to 34 percent, but they also did not take into account the costs associated with the competition.

Daly, Gates, and Schuttinga (1979) examined 31 programs and showed an average price reduction of 35 percent for competition on five missiles, a bomb, a guidance unit, and assorted electronic components. They speculated that savings for a "split award" would be about a 10 percent reduction, and a 20 percent reduction for winner-take-all competitions. This study failed to consider competition costs.

Drinnon and Hiller (1979) expanded upon the work of Lovett and Norton by reviewing 45 additional programs. They also found savings reductions ranging from –16 percent to 67.7 percent, with the median around 39 percent. Like the previous studies, most of the items were subassemblies and small electronic components. Major systems in their study only achieved 10–18 percent reductions (i.e., foreard area alerting radar [FAAR], tube launched optically tracked wire guided missle [TOW] and Shillelagh) DEFINE. They likewise did not take into account the costs associated with competition.

Kratz and Cox (1982) expanded upon the conceptual framework of Drinnon and Hiller, and suggested that what transpired with the creation of competition was a

**William N. Washington** is an operations research analyst for the Directorate of Resource Management at HQ CECOM, Fort Monmouth, NJ. He is a graduate of DSMC's APMC 96-2, and the Army Acquisition Corps Senior Service College (1995); he received the Secretary of the Army's Award for Outstanding Achievement in Material Acquisition (1994). He is a member of the Army Acquisition Corps, and rated level three in fields A, K, and S.

shift and rotation of the learning curve, with an immediate drop in the first unit cost and a steeper learning curve. In applying their approach to five missile procurements, they found that the first unit cost was reduced by between 14 percent (4 percent shift and 8 percent rotation) to 46 percent (14 percent shift and 13 percent rotation). The model outlined in this approach is available from the Defense Systems Management College under the name of the Competition Evaluation Model (CEM), version 2.0 (1992). Beltramo (1989), however, took exception with the logic behind this model, and in a study performed for the Naval Center for Cost Analysis found only one example out of six cases where there was a shift and rotation. In the remaining cases, he found a downward initial shift with an upward rotation (i.e., a lower price for the first competitive lot, followed by a flatter learning curve than expected for the sole source).

It is hard to determine from these early studies how beneficial competition is to the procurement process, since they do not take into account the costs associated with conducting the competition, and the studies vary considerably in terms of consistency of results from one study to the next, for the same data. However, it does seem obvious that there is a general cost savings associated with competition, especially on spare parts.

In an attempt to compare the studies' results for this problem of consistency, I reviewed the same procurements in different studies (see Table 1). In these systems (i.e., data points), there was considerable variability in results from one study to the next—where there should have been substantial similarity. For instance, some studies described a procurement as having produced a cost savings; other studies pronounced the same procurement to have caused a loss. Most striking were results for the Sidewinder 9D/G and the Sparrow 7F competitions, which were significantly different in different studies; other systems showed considerable variation from one study to the next. This variability can be attributed to the studies' use of different definitions, and, as a result, different costs were applied from one study to the next. Hampton (1984) presents a good example of how this occurs. On one system, the Shillelagh, he shows that savings can vary

**Table 1. Variance Among Studies on Cost Savings**

| STUDIES | ZUSMAN | LOVETT | DALY | DRINNON | KRATZ | GREER | |
|---|---|---|---|---|---|---|---|
| SYSTEMS | | | | | | | Range |
| TOW | 48 | 9 | 9 | 12 | 20 | 26 | 40 |
| SHILLELAGH | 0 | 6 | - 8 | 9 | – | - 5 | 17 |
| BULLPUP | 14 | – | 32 | 27 | 46 | 18 | 32 |
| SIDEWINDER 9D/G | – | – | - 5 | 1 | – | - 71 | 72 |
| SIDEWINDER 9B | – | – | 1 | - 6 | 17 | – | 23 |
| SPARROW 7F | – | – | – | – | 14 | - 25 | 39 |

from –14 percent to 22 percent depending upon the data used, statistical methods, and definition of what constitutes savings. The foregoing studies show that it is hard to place a firm number on the actual savings associated with competition.

## Second Phase of Studies on the Benefits of Competition

Either as a result of the previous studies, or perhaps relating to increasing public interest in reducing defense costs, the DoD Cost Analysis Symposium of 1982 generated four papers on the topic of competition. These papers attempted to provide a more comprehensive approach to the question of savings resulting from competition; and also took a slightly different approach to research in this area, discussing several constraints that should be considered prior to a competition decision.

Trainor's review (1982) of Lovett and Norton and of Daly, Gates, and Schuttinga found that the majority of items (48/55) compared in these studies were nonmajor systems with unit costs of between $4,100 and $8,400 (fiscal year 1980 dollars). The only major weapons systems in these studies were one ship, one medium-size missile, and one small helicopter. He suggests that the results concerning the benefits of competition should only be applied to nonmajor system procurements. In addition, Trainor gives several reasons why competition may not either be practical or produce cost savings in the future, especially if current trends for defense contractors continue. These points are rather interesting, and in light of our current defense draw-down, will be discussed later.

Watkins (1982) followed up on the Kratz and Cox model for estimating the slope for competitive contracts. He discussed the historical data by commodity area (e.g., electronics, missiles) and what the rotation and shifts could be for them based upon previous contracts. He also proposed the use of "should costs," using the model to determine the learning curve that the contractor should agree to for production.

Smith and Lowe (1982), like Watkins (1982), looked at the Kratz and Cox (1982) model for estimating the slope differences between competitive and sole-source procurements. Their results supported the shift and rotation premise and suggested that between a 15 and 25 percent savings on spare parts could be achieved by competition. They did not mention whether the cost of the competition was taken into account.

Carrick (1982) discussed experience curves and the factors that influence them. Like Trainor (1982), he mentioned that contractors have several problems in their estimation process for competitive bids that may cause cost growth over the initial estimate. For instance, in the DIVAD program the winning contractor had not even generated designs for several of the equipments, yet submitted a cost estimate for them. Also, in the Viper and Copperhead programs, neither of the winning contractors adequately understood the technology underlying their designs, much less the exceptional difficulties in defining and implementing a high rate of production technology. These examples point out that one cannot just use the bid price from the contract as data for competition studies; the actual production costs should be used.

## More Comprehensive Studies on Competition

Following this period, the research on sole-source versus competition changed from somewhat simple comparisons to multiple factor analyses. These studies recognized that there were several possible factors that could come into play in affecting the costs associated with contracting. A number of these well-done studies were master's theses from the Air Force Institute of Technology.

Brost (1982) conducted a regression approach to determine the savings associated with competition, comparing the estimated sole-source cost on spare parts procurements to the actual competition prices, controlling for inflation and commodity type. His results ran counter to the earlier spare parts studies, and indicated a general negative trend as a result of competition. These results could have been influenced by the small number of procurements that met his criteria for inclusion into the study (36). Further, while recognizing that there were additional costs associated with competition, the study did not add these costs to the competition side of the equation; had they been, the results of this analysis would be even less favorable toward competition.

Zamparelli (1983) followed up on this spares analysis, and, in turn, found some savings associated with competition (4.1 to 11.2 percent). But in several instances competition was not found to be beneficial. For example, where relatively few companies can supply a particular aircraft engine's spare parts, even if proprietary data are not involved, competition was not effective in reducing costs, since the second source of supply may need to retool and change its machine specifications in order to produce the parts. In addition, when the spare parts exceeded $1,000 in unit costs, competition did not save money. Finally, there were some instances in which competition increased costs by two to eight times the sole-source cost—but these instances may stem from the part not being manufactured any longer. The study, like the previous studies, did not consider the cost of competition in its analysis.

Greer and Liao (1983) investigated contractor profitability and capacity utilization in relation to competition cost savings. Using three of the six missile competitions from Kratz and Cox (1982), they concluded that competition produces greater savings when firms are at low capacity. But when capacity utilization was high, there was little benefit attributed to competition. The worst cases occurred when capacity utilization was above 80 percent. In those instances, there were net losses associated with competition.

**"The worst cases occurred when capacity utilization was above 80 percent. In those instances, there were net losses associated with competition."**

Heinz (1983) looked at a factorial approach to sole source versus competition. He suggested that for the early development of armament systems sole sourcing was best, but, as the systems matured to the 6.5 level, competition became more favorable. His suggestions seemed to principally be related to the complexity of the system, in that the more complex the process, the more appropriate sole source became.

Hampton (1984) produced an excellent paper that reviews the above-mentioned studies, critiquing them upon their methodology and suggesting a more appropriate approach to determine if competition was worthwhile. Generally, he came to the conclusion that competition was not always cost effective or practical, and that in order to determine if there were any advantages to a system going competitive, a cost–benefit analysis should be performed that would take into account all the costs associated with the government and the contractors, and would use discounted dollars in accordance with OMB Circular A-94. His paper was basically broken into three sections. The first section was a complete discussion of previous research, then the factors that should be considered in determining if competition were cost effective, and, third, a discussion of a cost–benefit approach that could be applied to determine the reasonableness of competition. He also discussed, in the second section, several studies that took these additional government and contractor costs into account, and found that competition was not cost effective for those systems.

**Gansler discusses how the "fair and open environment" that Congress has created can lead to too many bidders entering the competition—more than is good for either the government or for the contractors themselves.**

Gable (1985) looked at whether competition reduced spare parts procurement costs. The study did indicate a savings associated with competition, but he states that competition is not always possible for several reasons (e.g., inadequate or missing data, proprietary rights, shrinking industrial base). He recognized also that there are several costs associated with competition that might outweigh the benefits in gross savings (competition personnel costs, contracting personnel costs, increased processing time required to conduct the competition, and the additional paperwork required).

Presar (1986) discussed how the pressure to increase competition would cause increasing workload requirements on the commodity commands, in terms of personnel and time to conduct these procurements. These manpower requirements would be borne by the commodity commands and would not be funded by the weapons systems nor out of the normal command's budget, thus causing the offices in those commands to absorb the increased man-hours out of their existing workforce.

Berg, Dennis, and Jondrow (1986) performed a literature review of the previous studies on sole-source versus competitive procurement. They recognized the inconsistencies of the previous studies and attempted to outline why differences may have occurred (e.g., use of differing data, different adjustments, different assumptions). Their recognition of these possible problem areas and the subsequent effect upon the previous studies was quite good. They also suggested that the price improvement curve model of Kratz and Cox (1982) may not take enough variables into consideration for true forecasting purposes.

In his book *Affording Defense*, Gansler (1989) discusses how the "fair and open environment" that Congress has created can lead to too many bidders entering the competition—more than is good for either the government or for the contractors

themselves. He describes one case in which DoD spent time and money evaluating fifty bids for a few-hundred-dollar item. Situations like these hardly make sense, and can promote inexperienced, weak manufacturers, when DoD with its substantial buying power should be obtaining the most effective weapons for the lowest cost. He also stresses the importance of continuous competition, where, if possible, not only the initial procurement is competed but also the production contracts; preferably with a leader–follower award, so that there continues to be a competitive pressure on manufacturers. He emphasizes, however, that competition should make sense, and that, in an environment stressing competition and low cost, the quality of DoD items could be threatened if it is carried too far. He sums up these concepts with the following statement: "Competition for its own sake is clearly wrong; however, when competition makes good management sense and when best value is emphasized, that is a different story."

Kitfield (1989) discusses whether some programs represented as competitive were really so. He also describes a Navy study of eight separate weapons systems that estimated the cost of bringing on a second source at 2–4 percent of the total cost of the procurement.

Boger, Greer, and Liao (1990) assert that competition in weapons systems procurement does not always produce savings. They reemphasize Greer and Liao's (1983) previous study, where capacity utilization above 80 percent produced losses when systems were competed. They also discussed several factors that could make competition less effective than in private industry: when the government is the sole buyer, with only limited production and few companies capable of producing the items, the government is required to help establish the second source.

Flynn and Herrin (1990) show that the Navy has been having success with competitive procurements on large weapons systems, achieving a 14 percent savings (these savings did not take all competition costs into account, however). They estimate that the startup costs for the second source represented 2.4 percent of the total program costs. But they temper the 14 percent estimate by saying that the previous procurements occurred during the 1980s defense buildup, and may not hold in the current defense drawdown period with reduced quantities.

Carlson, Hamre, and McNicol (1990) discussed several issues concerning weapons system competitions at the DoD Cost Analysis Symposium (1989). This was the second time that a majority of symposium papers dealt with competition (1982). The authors covered several areas of possible concern for future competition, such as system complexity and whether complexity itself would preclude dual sourcing. They also asserted that dual sourcing may be driving companies to share less information with one another, out of fear that they may end up competing at a later date, and that this impaired the technical capability associated with new defense technologies. They also stated that the current

**"...the current preoccupation with price is not in keeping with the new trends in total quality management, and that best value should be the principal goal for defense procurements.."**

preoccupation with price is not in keeping with the new trends in total quality management, and that best value should be the principal goal for defense procurements.

Elliot (1990) reviewed the impact of competition on the quality of the items procured. The study found no significant difference in quality as a result of changing from a sole-source to a competitive producer. However, these procurements were for spare parts and may not be representative of major systems or components under development.

Wandland and Wickman (1993) found, as have authors of previous studies, that competition resulted in reduced costs over sole-source procurements, though the difference was not statistically significant. The study also examined the question of whether contractors might be buying in on competitive contracts. Here they found that counter to expectations, competitive contracts had less cost and schedule growth than sole-source contracts, though the differences were not statistically significant. Like previous studies, the costs associated with competition were not considered in their results, though they were aware of several competition costs (i.e., technology transfer to second source, additional government management, time value of money, purchasing reprocure-ment data, special tooling and test equipment).

**"Given the variability of results... it seems prudent to take a conservative approach to the question of when competition should be used."**

## Discussion

Given the variability of results from the preceding studies, and the subsequent recognition that several factors are involved in the ultimate determination of whether competition is cost effective, it seems prudent to take a conservative approach to the question of when competition should be used. Like several other investigators in this area, I have come to the conclusion that competition "savings" are dependent upon several factors, ranging from industrial base issues to how costs are defined in the analysis. Trainor (1982) and Gable (1985) discussed several industrial base issues that could influence production costs, and that should be considered when deciding whether to use sole sources or competition to procure an item.

One of these issues is **production rate.** In single-line production (where only one type of item can be produced on the production line), higher production rates allow more efficient production, and so, lower costs. This factor was coming into play in 1982, with decreasing production rates, and has continued to be a factor as weapon systems have become more complex, and require higher sophistication than standard manufacturing products.

The **stable production rate** is another important factor. In single-line production, a stable production rate allows for more efficient production, and so, lower costs. Stable production rates were becoming a problem for military manufacturers in 1982, and have continued to be a factor as funding for military programs has undergone continuing readjustments, which in turn causes production slippages.

**Production quantity** is a combination of the previous two factors. In single-line

production, large quantities allow more efficient production, and so, lower costs. This factor had been decreasing for 10 years prior to 1982, and continues to decrease in the present environment.

**Time required to stabilize design** is another element to consider. Unless the design is firm, there is the possibility of cost growth. The increased complexity and testing requirements of weapon systems back in 1982 prompted this concern, which has continued to increase with the current sophistication and complexity of state-of-the-art systems. Some examples from Carrick's study (1982) were the DIVAD program, in which the winning contractor had not even designed several of the components when it submitted the bid. In the Viper and Copperhead programs, neither of the winning contractors adequately understood the technology or the high rate production techniques required when they bid on these systems.

**Capacity utilization** (in terms of both workers and facilities) is another issue that affects savings. As a company's plant utilization increases, the associated costs for its product decrease because of a reduction in overhead and excess capacity. This point was also recognized by Greer and Liao (1983) and Boger, Greer, and Liao (1990): When capacity utilization exceeds 80 percent, the superiority of competition over sole-source acquisition begins to diminish, perhaps because companies' efficiencies then operate at about the same level, and their costs are similar. Defense contractors continue to merge, and most are now operating at or near full capacity; they cannot achieve significant savings by reducing excess overhead.

**Special production skills and facilities** also affect the sole source versus competition decision. It is easier to establish a second production source if the need for specialized skills and facilities does not exist. However, with weapon systems becoming increasingly unique, only limited facilities are available to produce some systems (e.g., tanks, submarines, aircraft carriers), so that the pool of competitors for an increasing number of weapon systems is reduced. Zamparelli (1983) found that relatively few companies could supply the components to manufacture aircraft engine parts.

It is difficult to establish a second production source if **production drawings** are not available. As funding has become tighter over the years, several programs have opted for reducing the number of system drawings for their components, or not updating those drawings as design modifications have changed the components.

**Proprietary data rights** also affect the sole-source versus competition decision. It is difficult to establish a second source if the system or component uses proprietary information. Many contractors incorporate components and parts in their systems for which they hold the proprietary rights.

In addition, several costs associated with competition must be taken into account to determine if competition will really save money. Hampton (1984) and Beltramo (1990) discuss several of these in detail:

- the source selection costs, which includes both the government personnel and facilities required, along with the contractor's cost to develop the proposal;

- second source development costs, such as updating the technical data

package, special tooling and test equipment required, cost of transferring the technical data to the new source, and first article testing;

- other possible liabilities to the government, concerning the undepreciated assets that the government may have to pay for, or furnish to the new source;
- quantity and learning curve losses in production, if quantities are split between several sources;
- increased contract administration costs, if quantities are split between several sources;
- increased technical data administration cost for updating more than one source; and
- company-funded research and development costs that need to be recaptured by the original developer.

Added to these are the logistics costs associated with maintaining multiple versions of a system in the inventory, and the required spare parts unique to each version. These costs have not been discussed in the literature. Tied into this is the increased training required for repair of the different versions, and their respective technical manuals.

To thoroughly cover the topic, I discussed these issues with the leading professors and experts in the field: Beltramo (1996), Fullerton (1995), McAfee (1995), Rao (1995), Rogerson (1995), Vincent (1995), Wilson (1995), and Yao (1995). From these discussions I learned of additional studies and books the initial literature searches did not uncover.

Anton and Yao (1987, 1989, 1990, and 1992) have published several theoretical papers on the effects of full costing knowledge versus incomplete information on the bidding process. They point out that the developer's production experience provides a cost advantage over a second-source bidder, but this pricing advantage can be offset if is not opened to competition until later, and the initial cost information is provided to all bidders. They also note that in an environment with unequal cost information, both the bidder and the buyer benefit from a split award over a winner-take-all award; in an open cost knowledge environment, the buyer receives a lower cost under a winner-take-all process.

Recently, Fullerton (1995a and 1995b), Fullerton and McAfee (1996), and Taylor (1995) have expressed some novel and interesting proposals concerning competition. These are termed "research tournaments," in which the competition procedure is structured as an auction and prototype competition, with the winner awarded a "prize" for the best product. The auction component consists of the participants paying a fee for entering the tournament, which could be pooled across the participants to defray the cost of the prize, or offset the cost of conducting the competition. This prize could either be a set amount of money based upon what the government determined the work effort to be worth, or, if the contract award was large enough or had commercial applications, the award would merely be the winning of the contract, since the follow-on work would generate sufficient commercial incentive.

An article on optimal procurement mechanisms by Manelli and Vincent (1995) is similar to the work of Anton and Yao above (1987, 1989, 1990, and 1992) and looked at theoretical competitions. He proposed that the optimal competition environment would be first to offer to a select group of companies, in a sequential process, a fixed price to perform the work, and if they all should reject the price, then hold an auction.

## CONCLUSIONS

This review of the competition-versus-sole-source procurements literature makes apparent the following points. First, there is probably some rationale supporting competitive over sole-source procurements, but not all competitive procurements produce savings; and the savings are probably far less than 25 percent. Next, one should consider several factors before a competitive procurement is chosen; these include production quantity, complexity of the item, capacity utilization of the industry involved, special skills, and sufficient data on the item. In addition, decision makers should probably perform a cost–benefit analysis before choosing competitive procurement, to determine if that avenue will actually result in any savings. Lastly, competition is probably the best choice for acquisition of low-dollar-value spare parts required in considerable quantity, or for component parts and systems that are jointly and extensively used by private industry.

Currently, competition is the prescribed means of procurement, but we should be aware of its ramifications both for private industry and the military. The current hypersensitivity of private industry concerning research and manufacturing technologies (apparent from companies' great concern about sharing information with other contractors, for fear that they may be competing in the future) is one result of this policy. Carlson (Carlson, Hamre, and McNicol, 1990) discussed this effect with Hamre and McNicol at the 1989 Department of Defense Cost Analysis Symposium, and pointed out that in the past, when specific companies had "baronies" for a particular area, they maintained top-notch engineers for long periods of time at one location. These groups of experts generated a research synergy that led to the development of new technologies and a willingness to share technical information with other industries. Carlson's statement that this situation no longer exists has recently been echoed by industry representatives who describe today's environment as "kill or be killed" (*National Defense*, 1996). Companies hide what they are doing, and do not allow their employees to discuss their work at symposiums like the American Defense Preparedness Association, or the National Industrial Security Association meetings. This, in turn, he stressed, handicaps development of new technologies in these defense industries, and drives the armed services to depend more on commercial developments to generate the high-technology equipment required to maintain an edge over other countries. Hamre pointed out the current overemphasis on cost cutting, which runs contrary to principles of total quality management, where price is not the primary issue. This point of view has caused a change in recent years to "best value" competitions, where quality and value are considered in relation to price.

## References


Anton, J. J., & Yao, D. A. (1987). Second sourcing and the experience curve: Price competition in defense procurement. Rand Journal of Economics, 18(1), 57–76.

Anton, J. J., & Yao, D. A. (1989). Split awards, procurement, and innovation. Rand Journal of Economics, 20(4), 538–552.

Anton, J. J., & Yao, D. A. (1990). Measuring the effectiveness of competition in defense procurement: A survey of the empirical literature. Journal of Policy Analysis and Management, 9(1), 60–79.

Anton, J. J., & Yao, D. A. (1992, May). Coordination in split award auctions. The Quarterly Journal of Economics, 681–707.

Beltramo, M. N. (1989, March/April). Shift and rotate, cha, cha, cha. Program Manager, 6–8.

Beltramo, M. N. (1990, January/February). Exposed: The real truth about estimating economic effects of competition. Program Manager, 16–18.

Berg, R. M., Dennis, R. L., & Jondrow, J. M. (1986, January). Evaluation of models and techniques for estimating the effects of competition. Center of Naval Analysis Report (CRM-86-15). Alexandria, VA: Naval Planning Manpower and Logistics Division.

Boger, D. C., Greer, W. R., & Liao, S. S. (1990). Competitive weapon systems acquisition: Myths and facts. In D. C. Boger & D. A. Nussbaum (Eds.), Competition in weapon systems acquisition: Cost analysis of some issues. Papers and discussions from the 23rd Annual Department of Defense Cost Analysis Symposium, Leesburg, VA, September 6–8,1989, Naval Postgraduate School, Monterey, CA, September.

Boger, D. C., & Nussbaum, D. A. (1990). Competition in weapon systems acquisition: Cost analysis of some issues. Papers and discussions from the 23rd Annual Department of Defense Cost Analysis Symposium, Leesburg, VA, September 6–8,1989, Naval Postgraduate School, Monterey, CA, September.

Brost, E. J. (1982, September). A comparative analysis of sole source versus competitive prices in the acquisition of weapon system replenishment spare parts. Master's thesis, Air Force Institute of Technology, Wright-Patterson AFB, OH, School of Systems and Logistics.

Carlson, W., Hamre, J. J., & McNicol, D. L. (1990). Competition in weapon system acquisition: A roundtable discussion. In D. C. Boger & D. A. Nussbaum (Eds.), Competition in weapon systems acquisition: Cost analysis of some issues. Papers and discussions from the 23rd Annual Department of Defense Cost Analysis Symposium, Leesburg, VA, September 6–8,1989, Naval Postgraduate School, Monterey, CA, September.

Carrick, P. M. (1982, September). Experience curves on five army programs. Monterey, CA: Naval Postgraduate School.

Carter, G. A. (1974, December). Directed licensing: An evaluation of a proposed technique for reducing the procurement cost of aircraft (R-1604-PR). Santa Monica, CA: Rand Corp.

Competition Evaluation Model (CEM), (Version 2.0) [Computer software]. (1992, December). Fort Belvoir, VA: Defense Systems Management College.

Daly, G. G., Gates, H. P., & Schuttinga, J. A. (1979, September). The effect of price competition on weapon system acquisition costs (P-1435). Institute for Defense Analyses, Program Analysis Division.

Drinnon, J. W., & Hiller, J. R. (1979, December). Predicting the costs and benefits of competitive production sources (TASC Report 1511).

Elliott, R. S. (1990, September). Impact of competition on quality (DLA-90-P81018). Alexandria, VA: Defense Logistics Agency.

Flynn, B., & Herrin, D. (1990). Results of competitive procurements of Navy weapon systems in the 1980s. In D. C. Boger & D. A. Nussbaum (Eds.), Competition in weapon systems acquisition: Cost analysis of some issues, Papers and discussions from the 23rd Annual Department of Defense Cost Analysis Symposium, Leesburg, VA, 6–8 September 1989, Naval Postgraduate School, Monterey, CA, September.

Fullerton, R. L. (1995a, March 17). Tournaments and competition in defense acquisition reform. Doctoral dissertation, University of Texas, Austin, TX.

Fullerton, R. L. (1995b, September). Using auctions to reward research tournament winners. Draft paper.

Fullerton, R. L., & McAfee, R. P. (1996, January 17). Auctioning entry into tournaments. Draft paper.

Gable, J. G. (1985, September). The rapid rise in the cost of replenishment spare parts: Are we making progress? Master's thesis, School of Systems and Logistics, Air Force Institute of Technology, Wright-Patterson AFB, OH.

Gansler, J. S. (1989). Affording defense. pp. 181–189.

Greer, W. R., & Liao, S. S. (1983, October). Cost analysis for dual source weapons procurement. Monterey, CA: Naval Postgraduate School.

Hampton, R. J. (1984, June). Price competition in weapons production: A framework to analyze its cost effectiveness. Maxwell AFB, AL: Air University.

Heinz, H. A. (1983, December). Analysis of the acquisition strategy decision process among three dimensions of the Acquisition Improvement Program. Dover, NJ: Army Armament Research and Development Command.

Kitfield, J. (1989, July). How competitive is competition? Military Forum, 42–45.

Kratz, L., & Cox, L. (1982, May). Analysis of AMRAAM acquisition alternatives: Phase II (TASC Technical Report 4049).

Lovett, E. T., & Norton, M. G. (1978, October). Determining and forecasting savings from competing previously sole source/noncompetitive contracts. Fort Lee, VA: Army Procurement Research Office.

Manelli, A. M., & Vincent, D. R. (1995). Optimal procurement mechanisms. Econometrica, 63 (3), 591–620.

Defense industry executive outlines actions for preserving viable base. (1996, April). National Defense, 15.

Olson, A. E., Cunningham, J. A., & Wilkins, D. J. (1974, January). A cost–benefit analysis of competitive versus sole source procurement of aircraft replenishment spare parts. Master's thesis, Air Force Institute of Technology, School of Systems and Logistics, Wright-Patterson AFB, OH.

Presar, M. E. (1986, September). Assessing the impact of recent competition related legislation on the workload of systems contracting personnel at Air Force Systems Command product divisions. Master's thesis, Air Force Institute of Technology, School of Systems and Logistics, Wright-Patterson AFB, OH.

Smith, C. H., & Lowe, C. M. Jr. (1982, September). Sole source and competitive price trends in spare parts acquisition. Fort Lee, VA: Army Procurement Research Office.

Taylor, C. (1995, September). Digging for golden carrots an analysis of research tournaments, American Economic Review.

Trainor, R. (1982, September). Price competition between major weapon system contractors. Department of Defense 17th Annual Cost Analysis Symposium, Arlington, VA.

Wandland, K. W., & Wickman, G. P. (1993, September). Analysis of cost and schedule growth on sole source and competitive Air Force contracts. Master's thesis, Air Force Institute of Technology, School of Logistics and Acquisition Management, Wright-Patterson AFB, OH.

Watkins, P. N. (1982, September). Competition in automotive commodities: Implications for competitive and non-competitive acquisition strategies. Warren, MI: Army Tank-Automotive Command.

Zamparelli, S. J. (1983, September). Competition in the acquisition of replenishment spare parts. Master's thesis, Air Force Institute of Technology, School of Systems and Logistics, Wright-Patterson AFB, OH.

Zusman, M., & Asher, N. (1974, March). A quantitative examination of cost quantity relationships: Competition during re-procurement and military versus commercial prices for three types of vehicles. Institute for Defense Analysis, Program Analysis Division, S-429.

## Interviews

Beltramo, Michael N. (1996), Beltramo and Associates, Los Angeles, CA.

Fullerton, Richard (1995), Assistant Professor of Economics, U.S. Air Force Academy.

McAfee, Preston (1995), Professor, Business School, University of Texas at Austin.

Rao, Vithala (1995), Professor, Johnson Graduate School of Management, Cornell University.

Rogerson, William (1995), Professor, Department of Economics, Northwestern University.

Vincent, Daniel (1995), Professor, University of Western Ontario.

Wilson, Robert (1995), Professor, Business School, Stanford University.

Yao, Dennis A. (1995), Associate Professor of Public Policy and Management, Wharton School, University of Pennsylvania.

# SELECTING EFFECTIVE ACQUISITION PROCESS METRICS

*Aron Pinker, Charles G. Smith, and Jack W. Booher*

Metrics for assessing the acquisition reform process are now being actively sought by the DoD. It is difficult to identify meaningful metrics that can be conveniently calculated. Using our experience from the Partnership Process for Electronic Warfare (EW) Acquisition, we describe a reasonable approach to effective selection of metrics. We examine DoD initiatives aimed at measuring acquisition reform, identify a process for establishing metrics, suggest a basis for ordering metrics, and provide examples of metrics.

This article is a result of the Secretary of the Air Force Electronic Combat Division's (SAF/AQPE's) effort to design a new approach to the acquisition of Electronic Warfare (EW) systems. SAF/AQPE assembled an EW Acquisition Partnership team to design an acquisition process that seamlessly integrates the warfighter's requirements with product development and testing. From its inception, the EW team recognized that improving the EW systems acquisition process requires identification of the baseline acquisition process for EW systems and definition, or development, of a new acquisition process. To attain this objective and demonstrate that improvement has been achieved, it is imperative to have some measures, or metrics, for comparing the old process (baseline) with the new process (acquisition reform). Here we present some of our insights on metrics that could be useful to the DoD acquisition community.

## PROBLEMS IN DEVELOPING METRICS

Most people who work with metrics recognize that it is not easy to identify meaningful metrics that can be conveniently calculated (Dellinger, 1994).

**"Metrics allow us to baseline where we are, identify the impediments to the process, and track the impact of management actions on processes and other process changes."**
**–Gen. Thomas R. Ferguson, Jr.**

The main consideration in Air Force acquisition reform is whether the new process enables us to field *better* weapon systems, *faster*, and *cheaper*.

The first problem with developing metrics for the acquisition process is that we cannot directly measure these attributes. So they are useless as metrics; we must use other, quantifiable, "surrogate" metrics instead. But it is not easy to decide what these surrogate metrics should be, and it is not always clear how they would contribute to the goal of fielding military systems that are better, faster, and cheaper.

A second problem with formulating metrics is the fact that a weapon system acquisition takes place over a long period of time. The success or failure of the acquisition is determined in retrospect by how well the weapon system has served the military. Consequently, we can assess the success of the acquisition process only in a post mortem. Such an assessment would, of course, be of merely historical interest and little practical use. We will later suggest a method for creating a top-down (or bottom-up) hierarchy of metrics that links surrogate metrics to the true metrics by means of Quality Function Deployment (QFD) (Fortuna, 1988) and the Analytic Hierarchy Process (AHP) (Saaty, 1980).

## DEVELOPING STANDARDIZED METRICS

As the defense acquisition system is being streamlined, DoD is also considering ways to measure the improvement as it occurs. Measuring improvement starts with identifying the changes in process brought about by acquisition reform and providing a comprehensive plan for estimating and measuring these changes. Dr. Paul Kaminski, Under Secretary of Defense (Acquisition and Technology) believes that the Pentagon should have Defense Department-wide metrics (Meadows, 1995). If this standardization is achieved, it would provide a useful basis for comparing the various acquisition reform initiatives.

This raises the question of which metrics can be shared by all commands and which would only apply to specialized activities. For example, while the EW acquisition community may have some metrics that are shared by the general DoD procurement community, EW may have some unique service-specific or area-specific metrics. Additionally, if different

**Aron Pinker** holds a M.Sc. in physics, mathematics, and meterology from Hebrew University, and a Ph.D. in mathematics from Columbia University. For a number of years he was a professor of mathematics at Frostburg State University. Dr. Pinker is the author of several books on physics, and numerous papers on mathematics, physics, and decision sciences. He produces the weekly newsletter *GPS* for *Air Power*.

**Charles G. Smith** holds a B.S. in industrial management from Syracuse University and a B.S. and M.S. in electrical engineering from the Air Force Institute of Technology. For more than three decades he has been involved in the DoD acquisition of avionics systems and support equipment. Mr. Smith has authored numerous papers on avionics standardization, logistics, and technology.

**Colonel Jack W. Booher, USAF (Ret)**, is the former division Chief of the Electronic Combat Division at the Office of the Assistant Secretary of the Air Force (Acquisition), Directorate of Global Power Programs. Mr. Booher is currently employed by Lockheed-Sanders.

**Table 1. Initial Metrics**

| TYPE OF METRIC | METRIC |
|---|---|
| *Cost* | Consumable item price index, military specification conversion price benefit |
| *Acquisition performance* | Contract defaults, contract changes |
| *Schedule* | Acquisition phase time, administrative lead time, multiyear procurements; FACNET transactions, logistics response time |
| *Commercial practices* | Contract specifications, credit card purchases |

commands have different senses of mission criticality, they would weight the shared metrics differently.

Consequently, using our experience from the EW Acquisition Partnership, we intend to describe a reasonable approach for selecting metrics. In the following sections we will examine DoD initiatives aimed at measuring acquisition reform, identify a process for establishing metrics, provide examples of metrics, and suggest a basis for selecting and ordering metrics.

## Recent DoD Initiatives

### Process Action Teams (PATs)

Last year Dr. Paul Kaminski and Colleen A. Preston, former Deputy Under Secretary of Defense for Acquisition Reform, chartered several process action teams (PATs) to recommend actions for reforming DoD acquisition practices and to define metrics for assessing the effectiveness of the recommended reforms. The PATs were fairly successful in identifying simplifications and improvements to reform DoD acquisition practices. The definition of metrics, however, has turned out to be a major difficulty. The PATs have struggled to come up with at least some metrics. Yet, they never explained the interrelationship and connection of these metrics to the over-all goal.

### The Tiger Team

After the PATs' attempts at defining metrics, the Defense Standards Improvement Council formed a metrics Tiger Team, led by the Office of the Assistant Secretary of the Army, Research, Development, and Acquisition (OASA/RDA), Acquisition Reform Office, to develop metrics and a method for collecting data for these metrics. This team has proposed a set of initial strategic outcome metrics for measuring the impact of acquisition reform. Preston has approved the strategic outcome metrics in Table 1 and has authorized the OASA/RDA to collect the necessary data.

It appears that the Tiger Team selected these metrics because they are relatively

easy to collect. From the warfighters' perspective, the category of "system performance" has been omitted. Also, the Tiger Team has not addressed the issue of quick integration of advanced technologies. The categories of metrics in Table 1 will probably be expanded in the future.

**"Because surrogate metrics are not true metrics, we need to know how strongly they represent the true metrics."**

Appendix A presents a list of the strategic outcome metrics that have been suggested to the Acquisition Reform Senior Steering Group. Appendix B presents the algorithms for computing the initial set of selected metrics.

### Aquisition Reform Benchmarking Group

On Sept. 18, 1995, Preston established the Acquisition Reform Benchmarking Group (ARBG), chaired by William E. Mounts from her office. The ARBG will receive, assemble, and assess data from these and other acquisition reform strategic outcome metrics. The group will also assess the suitability of other metrics proposed by the various acquisition reform PATs. Interim results can be found on the World Wide Web at:

http://www.acq.osd.mil/ar

## Conceptual Considerations in Selecting Metrics

### Defining True and Surrogate Metrics

Because our interest is in the acquisition process, we have chosen to define metrics for this process rather than metrics in general as shown in Table 1.

*Acquisition reform metrics* are the numerical values by which we gauge progress toward meeting acquisition reform objectives.

If the overall objective of the acquisition reform is to field *faster*, *better*, and *cheaper* weapon systems, then a true metric would be any numerical value that enables us to assess *how much* faster, *how much* better, and *how much* cheaper a given acquisition process is. Unfortunately, we do not have such true metrics; we do not know how to directly measure these qualities. The terms *faster*, *better*, and *cheaper* have so many possible meanings that we must restrict these terms to some of their more specific characteristics. To do this we have to use "surrogate metrics."

A *surrogate metric* is a measurable characteristic of the acquisition process that presumably reflects the behavior of a true metric.

Because surrogate metrics are not true metrics, we need to know how strongly they represent the true metrics. Moreover, some metrics may be better described as submetrics that together constitute a higher level. This grouping leads to a hierarchical structure of metrics with the many surrogate metrics at the bottom and a few true metrics at the top. This grouping also requires us to determine how the lower-level metrics contribute to the higher-level metrics.

## Brainstorming Potential Metrics

One can usually gather many potential metrics for a process. Follow these guide-

lines to brainstorm for potential metrics:

1. Identify the specific segment of the process that is to be evaluated.

2. Identify the pertinent properties of what is to be measured.

3. Identify types of potential metrics.

4. Select a few metrics and provide a rationale for the specific selection.

5. Find bounds on what is being measured.

## Avoiding Ineffective Metrics

Once you have discovered several potential metrics, determine which ones will be most useful. A good metric will be meaningful, logical, simple to express, understandable, repeatedly and quickly derivable, unambiguously defined, and derivable from economically collectible data.

In addition, a good metric will indicate trends, suggest corrective actions, and numerically describe the progress toward the objective.

While it is important to be able to identify a good metric, it is also important to know what is *not* a metric. Metrics are not charts, schedules, goals, objectives, strategies, plans, missions, guiding principles, counts of activity, single-point statistics, or rankings. Also, tracking a process is not necessarily the same as tracking a metric. In spite of this, one IPT suggested using the following measurements as metrics:

"Program managers should track use of military unique specifications and standards and report out at milestone/ program reviews" (OUST[A&T], 1994, p. 53)

"The Standards Improvement Executives shall be responsible for tracking implementation of all acquisition reform issues related to specifications and standards" (OUSD [A&T], 1994, p. 165).

Another IPT suggested that contractor responses to a questionnaire would serve as an input to a database, which would eventually be used for developing metrics. This proposed questionnaire included the following questions (OUSD[A&T], 1994, p. 27):

1. Are there any military specifications or standards required as a part of this solicitation which could be better served by a commercial specification?

2. Were any changes required in your routine manufacturing process specifically to accommodate this DoD purchase? Do you believe that the changes added value to the product?

3. Did you offer alternatives to requirements of any military specifications or standards? Do you feel that your alternatives were given adequate consideration by the procuring agency? Were any adopted?

4. How would you improve the solicitation to allow you, and other contractors, to quote a lower product cost while maintaining identical product performance?

Such questionnaires may solicit ideas for reform, but they seem to have little value for forming metrics, because they do not call for numerical, quantifiable responses. Could questionnaires be used for developing metrics? Could they be used to provide metrics that are of immediate use? The answers to these questions are not easy and may depend on the particular program for which metrics are developed.

## The Required Details for a Metric

The definition of a metric tends to be simple, because a metric should be easy to explain and calculate. Yet, from the technical point of view, many details of each metric must be specified to ensure commonality of the derived metrics. For each metric, at least, the following details must be specified:

1. Description of the population that the metric includes.

2. Identification of the source of data.

3. Precise definition of key terms.

4. Statement of the mathematical expressions that will be used to derive various values.

5. Specification of frequency of measurements to derive the metric.

6. Description of the graphics that will be used to display the data.

7. Specification of user's tolerance levels (i.e., "control limits").

8. Listing of desired outcomes expressed in terms of a positive or negative trend (not a numerical goal).

9. Linkage between the metric and the activity being measured.

10. Linkage between the surrogate metric and the true metric.

## Creating a Metric

Having laid out general guidelines and requirements for designing metrics, we now describe a step-by-step procedure for establishing and using metrics to assess improvement in the acquisition process. Follow this procedure to create a metric:

**Identify the purpose of the metric.** The purpose of the metric should reflect the purpose of the acquisition reform initiative and its mission, vision, goals, and objectives.

**Develop an operational definition of the metric**. Define the who, what, when, why, and how of this metric in sufficient detail to permit consistent, repeatable, and valid measurement of the acquisition process.

**Examine existing means of measuring**. Check whether existing metrics or process measuring means could be adapted to satisfy the operational definition of the metric. In other words, do not "reinvent the wheel."

**Generate new metrics**. In the past, most metrics were not process-oriented; they were usually related to final outputs,

products, or services. The focus is now on improving the new acquisition process so that superior final outputs are obtained. Currently, the underlying assumption for generating metrics is that by monitoring changes in the process we can assess process improvements.

**Conduct a "goodness of fit" check.** Check whether the newly generated metric satisfies the previously stated attributes of a good metric. Make sure that all the previously stated details can be provided for this metric. Check objectivity of the metric to ensure that the measurements or observations do not affect the outcome.

**Choose a mode of display**. Decide on the mode for presenting the metric. This decision will affect data collection and availability.

**Conduct a "sanity" check**. Acquire data for deriving the metric. Derive the metric for various instances and ask the customer to judge whether the metrics are meaningful. Does the metric measure what it is supposed to measure? Do the metric values correspond to intuition? If the answer is uncertain, return to the second step.

**Form a consensus**. Obtain consensus or buy-in from participants.

**Create a database**. Collect and analyze the metric's data over time and for different cases. Examine trends. Can you adequately explain counterintuitive metric values? For what lengths of time does the metric stabilize (i.e., does not deviate significantly from its mean)?

**Communicate the metric**. Be open to constructive criticism. Be ready to make adjustments.

**Employ the metric**. Metrics are just a means to an end—continuous process improvement. If there is confidence in the metric, then it should be used; otherwise, look for a new metric. Employing the metric allows you to refine it and make it an even better tool. (AFSC, 1991).

## Examples of Metrics

The following illustrate metrics at various levels of abstraction and areas of interest to the acquisition process. These metrics were collected from various sources, but most of them fall into the following categories: cost, acquisition performance, schedule, commercial practices, weapon system performance, and technology innovation.

**Program office overhead**. Program overhead as a fraction of total program cost.

**Specifications conversion**. Number of military specifications that have been replaced with industry standards.

**Specifications elimination**: Number of military specifications that have been eliminated; or, reduction in number of specifications and standards specified in a contract.

**Cost and pricing data**. Percentage of competitive, negotiated procurements requiring certified cost and pricing data; or,

ratio of the number of contract awards with cost and pricing data to the total number of contract awards.

**Funding stability**. The number of times a program changes in terms of quantity or cost, due to fiscal pressures external to program executive officers (or an equivalent management level).

**Program cost**. Change in program cost as a consequence of changed acquisition processes.

**Unit production price**. Change in unit production cost as a consequence of changed acquisition processes.

**Unit life-cycle cost**. Change in projected unit life-cycle cost as a consequence of changed acquisition processes.

**Operational performance versus cost.** Compare operational test results versus specified performance for accuracy and reliability with Average Unit Production Price Milestone I cost analysis improvement group estimates versus contractor production proposals.

**Commercial practices**. Compare business-as-usual versus commercial practices costs.

**Billing**. Effect of milestone billing versus cost billing.

**Oversight**. Number of oversight personnel per program budget size.

**Cost of performance**. The kind of system performance that can be bought for a given cost. To derive this metric it would be necessary in some way to quantify various combinations of system performance. This is a formidable task open to controversy.

**Commercial componentry**. Percent of commercially available componentry: dollars of commercial material to dollars of total obligation.

**System gestation time**. Time for a system or item to progress from concept exploration and definition to start of production and deployment phase.

**Contractor's past performance**. Contractor's ranking relative to other contractors on a predetermined set of criteria.

**Government-unique terms**. Proportion of government-unique terms and conditions to total number of such terms and conditions in a contract.

**Protests**. Number of bid protests per number of bidders.

**Regulatory cost premium**. DoD cost premium (%) equals contractor compliance costs ($) divided by value-added costs ($) x 100.

**Value-added costs**. Value added costs as percent of total costs where value-added costs equal total costs minus costs of material purchases, including subcontracts minus profit minus corporate general and administrative allocations.

**Contractor overhead.** Compare percentage of direct and indirect costs for top defense contractors as a group and indi-

vidually over time. Use the ratio of percent indirect costs to percent direct costs or dollars of indirect costs to dollars of direct costs.

**Consumable item price index**. Cost of a Defense Logistics Agency (DLA) predetermined set of consumables.

**Contract defaults**. Number of contract action defaults divided by the total number of contract actions.

**Contract changes**. Number of contract changes divided by the total number of contracts.

**Contract protests**. Number of protests resolved using the alternative dispute resolution process, and the number of protests that go to GAO and the General Service Board of Contract Appeals (GSBCA).

**Administrative lead time**. The average time from the signed formal requirements document to contract award.

**Production lead time**. Time from contract award to acceptance of first item or delivery.

**Engineering changes**. Number of engineering change proposals by program phase (demonstration and validation, engineering and manufacturing development, production startup).

**Alternative specifications and standards**. Number of contractors offering alternatives to military specifications and standards per 100 proposals.

**Alternative specifications and standards with incentives**. Percentage of solicitations resulting in incentive contracts where alternatives to military specifications and standards are offered.

**Dissemination time**. Time for processing and dissemination of requests for proposal, statement of work, and specifications and standards.

**Degree of use of simulation and modeling**. Percentage of contracts over $5 million using simulation and modeling to achieve cost performance tradeoffs.

**Degree of activity-based costing and management**. Percentage of contracts and contractors that use activity-based costing and management. (Activity-based costing identifies each category of cost [direct or overhead] and relates it to the specific product [e.g., military specification or standard, statement of work task, etc.] or product line that causes the activity to be needed and performed.)

**Marginal ownership cost**. Cost divided by operating time.

**Technology gestation**. Time from technological innovation to operational system integration.

**Cost as an independent variable**. Savings in a program when cost is used as independent variable.

**Operational goals**. Probability of achieving or exceeding stated operational profiles in a specified regime.

**Reliability goals**. Probability of system's satisfactory operation in given conditions.

**Maintenance goals**. Proportion of maintenance activities requiring a given level of maintenance.

**Integrability**. Ease of integrating the new system into an existing frame or organizational unit.

**Mean time between failures (MTBF).** The average number of operating hours between system failures.

This list is not exhaustive. Though most of these metrics have been taken from DoD sources, it is not clear whether all of them could serve as metrics for a specific service's acquisition process. Still, these examples provide some insights into the types of metrics that are being considered and the levels of abstraction that are needed.

## Quality Function Deployment and Analytic Hierarchy Process

The metrics in the preceding section are clearly at different levels of abstraction. For instance, "commercial practices" is more abstract than "oversight," and "integrability" is more abstract than "mean time between failures." Metrics that are not very abstract are usually easier to measure. Yet, highly abstract metrics are often more useful for assessing a process. We propose using the analytic hierarchy process (AHP) and quality function deployment (QFD) to create a top-down (or bottom-up) hierarchy of metrics that translates *what we can measure into what we are interested in measuring.*

### Using QFD and AHP to Weight Metrics

QFD is a structured process that facilitates a team approach to identifying and prioritizing customer requirements and translating these requirements into appropriate company requirements at each stage of the product life cycle—from research and development to manufacturing and support.

QFD's structured process consists of a set of interrelated matrices. These matrices are constructed by starting with the general goals (the "whats") that are to be achieved and then selecting the various means (the "hows") for achieving those goals. In the next step, the current "hows" become the goals (i.e., the "whats") and new "hows" are identified for achieving the new "whats". This process is repeated as many times as necessary to reach a desirable level of detail.

For any one matrix, the elements of the matrix are intuitive ratings (using the scale *weak = 1, medium = 3, high = 9*) of the contribution of a column means ("hows") to a row goal ("whats"). The relationship between the matrices is twofold: the columns (HOWs) of a matrix become the rows (WHATs) of the subsequent matrix, and the computed weights of a matrix's column become the weights of the subsequent matrix's rows. Thus, if a matrix entry is $m_{ij}$ and the row weights are $w_i$ then the computed column weights are:

$$\Sigma\, w_i\, m_{i1}/N,\ \Sigma\, w_i\, m_{i2}/N,\ \Sigma\, w_i\, m_{i3}/N,$$
$$\Sigma\, w_i\, m_{i4}/N, \ldots \Sigma\, w_i\, m_{ik}/N,$$

| WHAT | COST | ACQUISITION PERFORMANCE | SCHEDULE | COMMERCIAL PRACTICES | SYSTEM PERFORMANCE | TECHNOLOGY INNOVATION | |
|---|---|---|---|---|---|---|---|
| BETTER EW SYSTEMS | 3 | 3 | 1 | 1 | 9 | 9 | .40 |
| CHEAPER EW SYSTEMS | 9 | 3 | 3 | 3 | 1 | 1 | .35 |
| FASTER FIELDED EW SYSTEMS | 9 | 3 | 3 | 3 | 1 | 3 | .25 |
| | .29 | .13 | .10 | .10 | .18 | .21 | |

| WHAT | CONSUMABLE ITEM PRICE INDEX | MILITARY SPECS CONVER. ADVANT. | CONTR. DEFAULTS | CONTR. CHANGES | ACQUISITION PHASE TIME | ADMINISTRATIVE LEAD TIME | MULTI-YEAR PROCUREMENTS | FACNET TRANSACTIONS | LOGISTIC RESPONSE TIME | CONTR. SPECIFICATIONS | OVERHEAD | ACHIEVE OPER. GOALS | MTBF | INTEGRABILITY | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COST | 9 | 9 | 3 | 9 | 9 | 3 | 9 | 3 | 3 | 9 | 9 | 3 | 3 | 3 | .29 |
| ACQUISITION PERFORMANCE | 1 | 3 | 9 | 9 | 9 | 3 | 9 | 9 | 3 | 9 | 1 | 1 | 1 | 1 | .13 |
| SCHEDULE | 1 | 1 | 3 | 9 | 9 | 3 | 9 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | .10 |
| COMMERCIAL PRACTICES | 1 | 9 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | .10 |
| SYSTEM PERFORMANCE | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 9 | 9 | 3 | .18 |
| TECHNOLOGY INNOVATION | 1 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | .21 |
| | .06 | .09 | .05 | .12 | .10 | .04 | .11 | .06 | .04 | .09 | .06 | .06 | .07 | .05 | |

**Figure 1. Quality Function Deployment (QFD) for Acquisition Metrics**

where k is the number of columns and N $= \sum\sum w_i m_{ik}$ is the normalization factor. These weights become the weights of the rows for the subsequent matrix. Thus, at any given step the analyst can readily ascertain the relative contribution of a means to the end goals. An example of the QFD process for metrics is shown in Figure 1.

For the first matrix, the row weights could be derived using the pairwise comparisons of the AHP. The analytic hierarchy process, introduced by Saaty in 1971, applies a structured process in which only two factors are compared at a time (i.e., pairwise comparisons ) to a complex problem that is broken up into manageable super structures forming a hierarchy (Saaty, 1980). The preferences in a pairwise comparison are denoted numerically by a scale of one to nine. One denotes equal preference; nine denotes extreme preference. The mathematical algorithm of AHP converts these pairwise preferences into rankings of relative importance for each level. AHP provides a framework for the selection of a preferred alternative in a context of conflicting criteria. For the mathematical procedures and details of the process see Saaty (1980).

Our implementation of QFD for a hierarchy of metrics consists of the following steps:

**Step one: Form an IPT.** Organize an integrated product team (IPT) consisting of members that adequately represent the concerned community with respect to the system under consideration.

**Step two: Construct a hierarchy of metrics.** Charge the IPT with developing a hierarchy of metrics. For instance, the IPT could start with the first set of "whats" consisting of "better system," "cheaper system," and "faster fielded system." For the "hows", the IPT could choose the areas that Preston believes warrants the definition of metrics and some areas that are of importance to the warfighter. Thus, the IPT's initial set of "hows" could consist of cost, acquisition performance, schedule, commercial practices, system performance, and technology innovation.

It is possible that an IPT would come up with a different QFD matrix. However, we believe that it is best to have as much commonality as possible within the DoD community. In the next QFD matrix the "whats" are cost, acquisition performance, schedule, commercial practices, system performance, and technology innovation. See Figure 1 for an example of a hierarchy of metrics that the IPT could create.

**Step three: Derive initial weights.** Assign a numeric value to the metrics for "better system," "cheaper system," and "faster fielded system" that corresponds to their relative importance. In this case the IPT must decide the relative importance of only three metrics. This can be done directly without using AHP. However, each IPT member should perform this assessment individually and the IPT should average the values using the geometric mean.

**Step four: Fill out the first QFD matrix.** Using the scale *weak = 1, medium = 3, high = 9,* each IPT member fills out the first QFD matrix by answering the question "How strongly does the particular 'how' reflect the particular 'what'?" The IPT average matrix entry is the geometric mean of the corresponding individual entries. Note that we assume that any "how"

reflects any "what" to some degree, however weak. Thus, $m_{ij} \geq 1$.

**Step five: Compute the weights of the "hows."** If a matrix entry is $m_{ij}$ and the row weights are $w_i$, then the computed column weights are:

$$\Sigma\, w_i\, m_{i1}/N,\ \Sigma\, w_i\, m_{i2}/N,$$
$$\Sigma\, w_i\, m_{i3}/N,\ \Sigma\, w_i\, m_{i4}/N,$$
$$\ldots\ \Sigma\, w_i\, m_{ik}/N,$$

where k is the number of columns and N $= \Sigma\Sigma\, w_i\, m_{ik}$ is the normalization factor. These weights are the weights of the rows for the subsequent matrix.

**Step six: Repeat this process.** Repeat steps four and five as many times as needed to develop a QFD structure that links the true metrics to measurable surrogate metrics.

## Benefits From Applying QFD

Application of QFD to a hierarchy of metrics can provide the decision maker with significant insights. In the following we list some of these insights and illustrate them by means of the example in Figure 1 (see the first two matrices). Note that the entries in the QFD matrices of the figure are notional and that the rankings were derived using the QFD algorithms.

**Application of QFD to a hierarchy of metrics provides indications of the metrics on which to concentrate the data collection effort.** The first matrix in Figure 1 ranks the "hows" that contribute to the true metrics that measure the attainment of better EW systems, cheaper EW systems, and faster fielded EW systems. Metrics that pertain to schedule and commercial practices appear to have been ranked lowest (.10). This could indicate to a decision maker that his efforts should, perhaps, not be focused on these metrics if his resources are limited. The decision maker may wish to defer any such decision in the first step of the QFD process and wait to see the rankings in the second step, where a finer substructure is assessed. In this case, they will find that such metrics as contractor defaults, administrative lead time, and logistic response time rank very low. Now the decision maker is at a level of abstraction and detail that permits him to reconsider the collection of data for the measurable surrogate metrics.

**Periodic application of QFD to a hierarchy of metrics provides a means for assessing the sensitivity of lower-level rankings to changes in higher-level rankings.** Suppose that the DoD's emphasis has changed. Cheaper EW systems become more important (e.g., .40) and the faster fielding EW systems become less important (e.g., .20), while better EW systems remained as important as before. How would this change effect the ranking of the various metrics? The decision maker may *feel* that this change in emphasis is considerable and would affect the rankings of the metrics. However, the recalculation of "hows" rankings would show that they did not change, and change in current practices is not warranted.

Suppose that there is another change in DoD's emphasis. Cheaper EW systems become more important (e.g., .45) and the faster fielding EW systems become more

important (e.g.,.45), while better EW systems become less important (e.g., .1). In this case the importance of the cost metrics jumps to .39 while that of system performance drops to .08. Clearly, the decision makers would have to make some adjustments and shifts in their efforts if they are constrained by budgets.

**Application of QFD to a hierarchy of metrics provides a means for monitoring the relative importance of the metrics as a function of time.** As time passes, the "whats," the "hows," or both may change. If the QFD computations are repeated at fixed intervals of time we may observe a shift in the importance of various metrics. Such indications could provide the decision maker with the necessary time to prepare to shift from one set of metrics to another.

**"If the QFD computations are repeated at fixed intervals of time we may observe a shift in the importance of various metrics."**

**Application of QFD to a hierarchy of metrics provides a means for comparing the metrics for the acquisition of two distinct weapon systems.** Suppose that the QFD matrices in Figure 1 were obtained for an airframe and a similar set of matrices (with different entries and initial weights) was obtained for the avionics of this airframe. The differences in the rankings could then provide the decision maker with interesting information on potential problems with integration of the two systems.

**Application of QFD to a hierarchy of metrics provides a link between what we can measure and what we are interested in measuring.** Figure 1 indicates that the metric "contract changes" (.12 weight) is more strongly linked to the true metrics better EW systems, cheaper EW systems, and faster fielded EW systems, than the metric "logistic response time" (.04) weight.

## UNDERSTANDING THE USE OF METRICS

### STATISTICAL SIGNIFICANCE OF CHANGE

Suppose that we have identified a metric for a task or a process. Next, suppose that this metric is higher for the current process than for the previous process, and higher is better. Does this mean that the current process is better than the previous process? Not necessarily.

First, we must prove that the difference is statistically significant. However, this requires us to have a sizable sample of similar cases, make assumptions about the population probability distribution, and choose the statistics that will be used. Unfortunately, this kind of information is not available for military-unique programs. Consequently, we can rarely say with certainty that a positive change in a metric indicates a real improvement. We could say that an improvement was achieved only if the change in the metric was spectacular.

We have already noted that many metrics can be usually defined for a task or process. If all these metrics are independent and point in the positive direction, then we would be more certain that a positive improvement had occurred. On the other hand, if the metrics point in dif-

ferent directions, we cannot form any definite conclusion.

### Measuring Variations

While a set of metrics often does not allow us to draw solid conclusions, the comparative metric values could still benefit the acquisition process by indicating process variations that cause unsatisfactory performance. Thus, linkages between metrics of the left column and metrics of the right column in Figure 2 could serve as indicators of process variations. However, such linkages can be established with reasonable confidence only if data from repeatable processes is available.

Repeatable processes, highly desirable for drawing statistical inferences, are usually unavailable for a weapon system acquisition. Such an acquisition is in most cases a unique event. Moreover, the success or failure of the acquisition is determined in retrospect by how well the weapon system has served the military. Consequently, we can assess the success of the acquisition process only in a postmortem. Our challenge is to define metrics that show how the pieces of the process are doing and then to extrapolate these results to the entire process.

## Conclusions

We have outlined requirements and procedures for defining meaningful metrics for the acquisition process. It does not provide a prescription for the generation of metrics, however. For some processes useful metrics come readily to mind, for others one must employ substantial insight and creativity. But in each case the methods presented should be of practical use.

Since directly computable metrics tend to be limited in scope and specific in nature, we need to know how to combine the various metrics into one big picture. We propose to accomplish this by application of QFD or AHP. In these processes we do not actually combine the metrics,

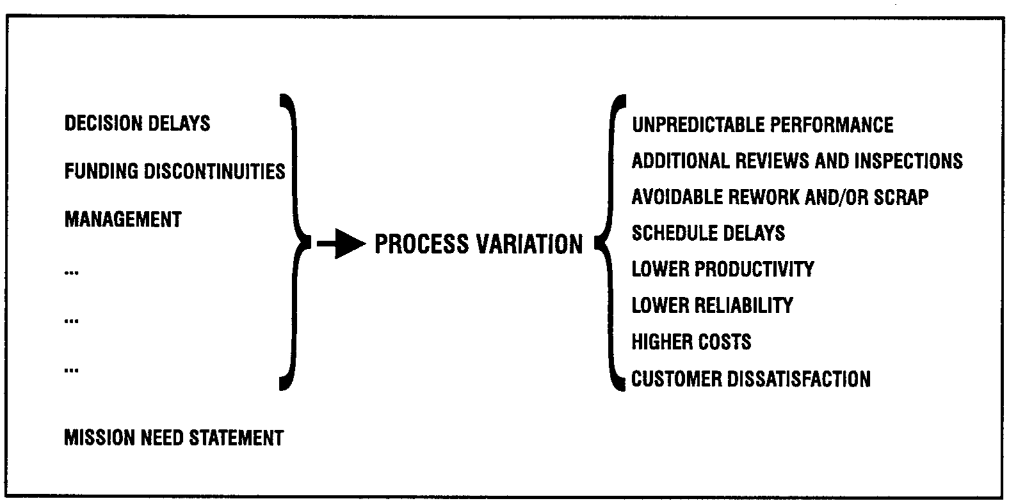



**Figure 2. Causes of Process Variation**

but rather gauge the relative contribution of a metric at one level to the metrics at a higher level. This seems to be a more prudent path to follow, because past efforts to combine metrics numerically have usually failed.

QFD offers interesting opportunities for linking metrics from one level of abstraction to a higher level. The ranking of metrics in the QFD process allows one to select the relatively important metrics. This prioritization could lead to more efficient strategies for assessing the acquisition process.

Definition of a metric is the beginning of a process of continual refinement for measuring process outcomes. As data for a metric is collected and the metric is used, much is learned that could shape an even better metric. Efforts to define useful metrics for the acquisition reform process must focus on measures that give insights into reform effects, not specific acquisition program indicators. Employing the methodology outlined in this paper should help to keep the focus where it ought to be—on reform processes.

**ACKNOWLEDGMENT**

We thank Maj. Art Huber for his constructive remarks.

## REFERENCES


Air Force System Command. (1991, August). The Metrics Handbook (p. 3-3). Andrews Air Force Base, MD.

Dellinger, L. (1994, November–December). Secretary Preston addresses DAU training and education conference. Program Manager, 21.

Fortuna, R. M. (1988, June). Beyond quality: Taking SPC upstream. Quality Progress, 23.

Meadows, S. I. (1995, July/August). Army grapples with means to appraise reform efforts. National Defense, 31.

Office of the Under Secretary of Defense for Acquisition & Technology. (1994, April). Report of the Process Action Team on Military Specifications and Standards. Washington, DC.

Saaty, T. L. (1980). The analytic hierarchy process. New York: McGraw-Hill.

## APPENDIX A

This list of strategic outcome metrics that has been proposed by the Defense Standards Improvement Council's Tiger Team.

**Cost.** Contractor overhead, cost premium for government unique requirements, consumable item price index, government administrative oversight, military specifications conversion price benefit.

**Acquisition performance.** Stability, consumable on-time deliveries, contract protests, contract defaults, supplier survey, contract changes.

**Schedule.** Acquisition phase time, administrative lead time, production lead time, multiyear procurements, FACNET transactions, logistics response time.

**Commercial practices.** Commercial contracts, cost and pricing data reduction, commercial content, contract specifications, commercial market share, credit card purchases.

# APPENDIX B

## COST

**Consumable item price index**. Total cost to DLA customers for representative sampling of consumable items expressed in constant dollars (FY$).

**Military specification conversion price benefit.** Cumulative cost avoidance using commercial specifications (performance specs, define (NGS), commercial item description (CIDs) and percent cost avoidance each year for Defense Logistics Agency (DLA) order. Applies only to items converted to commercial specifications since previous order.

## ACQUISITION PERFORMANCE

**Contract defaults**. The total number of contract action defaults divided by the total number of contract actions.

**Contract changes**. Waivers and deviations of major significance and Class I Engineering Change Proposals (ECPs).

## SCHEDULE

**Acquisition phase time**. Time for a system or item to progress from concept exploration and definition to start of the production and deployment phase. The metric is the average number of days between milestones (e.g., number of days between the signatures of MS 0 and MS I).

**Administrative lead time**. The average time from the signed formal requirements document to contract award. This excludes contracts for services and base support.

**Multiyear procurements**. The number and dollar value of multiyear procurements.

**Federal Acquisition Computer Network (FACNET) transactions**. The dollar amount of FACNET transactions divided by the total dollar amount of transactions in which simplified acquisition procedures have been used; the number of FACNET transactions divided by total number of transactions in which simplified acquisition procedures have been used.

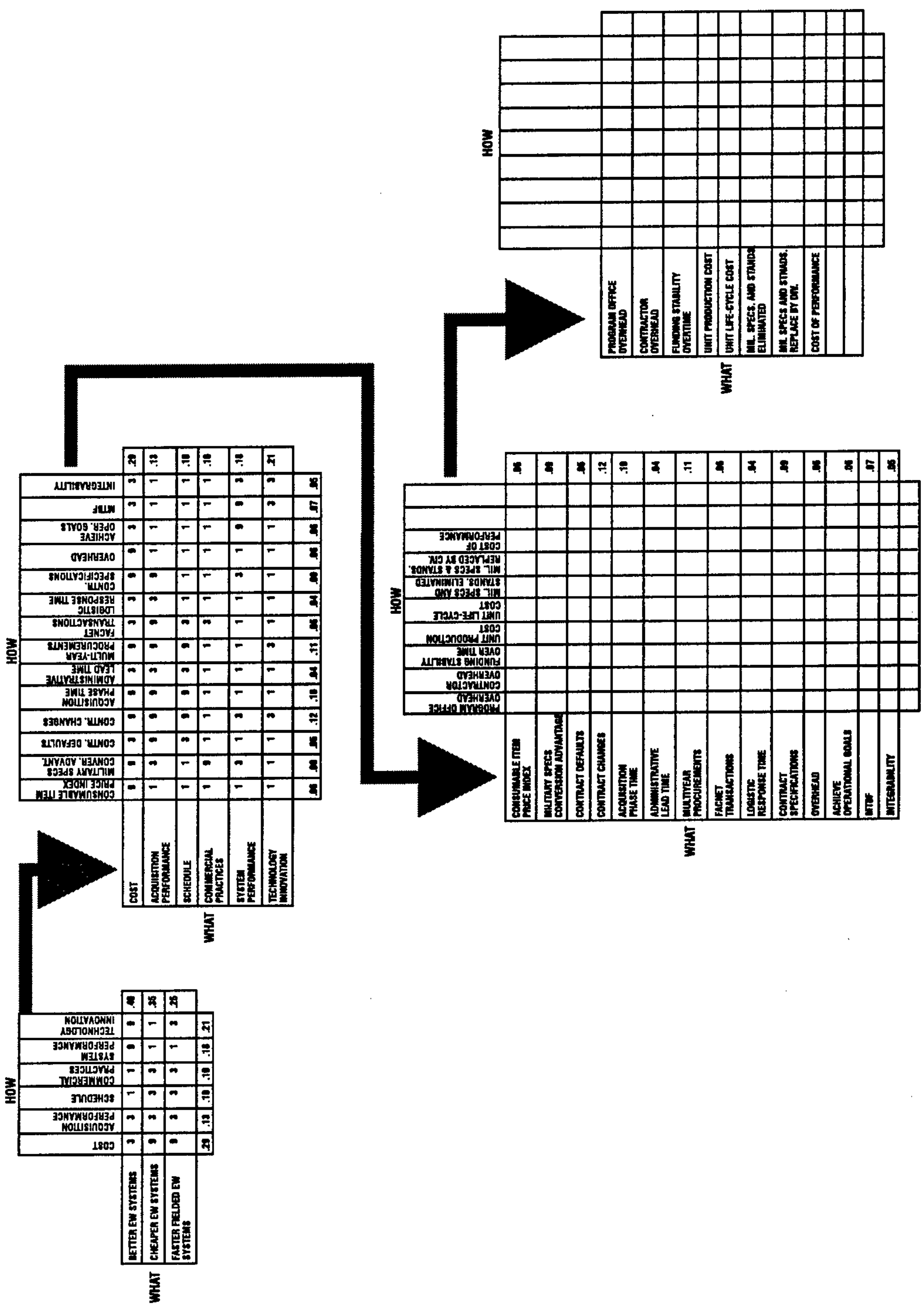
**Logistics response time**. The time between customer order and customer receipt of DLA items.

## COMMERCIAL PRACTICES

**Contract specifications**. The number of specifications and standards placed on contracts stratified by type: performance specifications (military performance [MIL-PRF], CIDs, Product Unique); NGS; old MIL-specs (assumed to be detailed); and, MIL-stds.

**Credit card purchases**. The number and dollar value of credit card purchases.

# APPENDIX B


HOW
WHAT
BETTER EW SYSTEMS
CHEAPER EW SYSTEMS
FASTER FIELDED EW SYSTEMS
COST
ACQUISITION PERFORMANCE
SCHEDULE
COMMERCIAL PRACTICES
SYSTEM PERFORMANCE
TECHNOLOGY INNOVATION
CONSUMABLE ITEM PRICE INDEX
MILITARY SPECS CONVERSION ADVANTAGE
CONTRACT DEFAULTS
CONTRACT CHANGES
ACQUISITION PHASE TIME
ADMINISTRATIVE LEAD TIME
MULTIYEAR PROCUREMENTS
FACNET TRANSACTIONS
LOGISTIC RESPONSE TIME
CONTRACT SPECIFICATIONS
OVERHEAD
ACHIEVE OPERATIONAL GOALS
MTBF
INTEGRABILITY
PROGRAM OFFICE OVERHEAD
CONTRACTOR OVERHEAD
FUNDING STABILITY OVERTIME
UNIT PRODUCTION COST
UNIT LIFE-CYCLE COST
MIL. SPECS. AND STANDS. ELIMINATED
MIL. SPECS AND STNADS. REPLACE BY CIV.
COST OF PERFORMANCE

# APPLYING DIALECTIC TO ACQUISITION STRATEGY

**David L. Peeler, Jr.**

Dialectic is the process of reasoning correctly. In the era of downsizing the defense budget and streamlining the acquisition process, the application of dialectic to weapon system (acquisition) programs is critical. Unless programs are debated properly, all programs and defense activities stand to lose. Dialectic operates to expose the best in each program idea, creating a synthesis that optimizes the selected approach. This article explains the concept of dialectic and how its use can improve the acquisition process.

Knowledge, both theoretical and practical, is key to success. Acquisition strategy formulation is the process of addressing a problem; it is an event-driven, iterative process that attempts to answer questions that involve the possible combinations of options or approaches available to achieve a system's desired objectives, within particular limitations. An acquisition strategy attempts to answer the why, what, when, who, and how questions that have to do with obtaining a system. The problem inevitably has many potential solutions. The dialectic of Kant, Hegel, and others provides a framework for answering the aforementioned questions; it can yield better insight into the convoluted nature of the acquisition strategy process.

The decision maker, or more aptly the decision participant, must be aware of the theoretical underpinnings of the debates in which he's engaged. This debate between approaches is known as dialectic. A theoretical understanding of dialectic by program managers (PMs) is crucial to the success of a program. The decision maker must understand the interplay and integration within a program and between it and others. Each aspect of an overall acquisition strategy is subject to question. Therefore, the PM must be ready to defend the program, in part or in total, in order to enhance the overall welfare of Department of Defense (DoD) acquisitions.

This goal is advanced solely through the give and take of debate. A dialectical approach yields a stronger solution to the overarching problem (i.e., the mission need [the why], as well as to the internal and external factors (the what, when, who, and how). Understanding the theoretical aspects of the necessary questions and issues, whose answers are integral to a suc-

cessful acquisition strategy, provides a framework for improved practical applications.

The first theoretical presentation of the dialectic in Western thought occurred in Ancient Greece. Plato writes of Socrates's dialogue with Phaedrus in which the nature or essence of dialectic is examined. Although the notions of dialectic can be traced further back through Oriental works, our study will begin with its appearance in the Occident. Aristotle, in the *Topics* (370 B.C./1987), addresses the essence and existence of dialectic:

> A dialectical problem is a subject of inquiry that contributes either to choice or avoidance, or to truth and knowledge, and that either by itself, or as a help to the solution of some other such problem. It must, moreover, be something on which either people hold no opinion either way, or the masses hold a contrary opinion to the philosophers, or the philosophers to the masses, or each of them among themselves.

Therein, Aristotle sets the stage for the modern, Western interpretation of dialectic; it is a problem involving opposing positions concerning the solution, either in part or total. As for the differentiation between the masses and the philosophers, recall that in Ancient Greece the Platonic hierarchy established philosophers as the best-suited leaders—that is, the decision makers. This hierarchy was used throughout the literature of the time.

Socrates further stipulates that a good dialectician is able to divide things by classes or subjects "according to the natural formation, where the joint is, not breaking any part ...." (Plato, 350 B.C./1937). This skill requires knowledge of the *thing* in question. Thus, dialectic involves a conflict of ideas in the pursuit of a solution to a problem—a problem that must be familiar to the dialectician.

The notion of dialectic again surfaces in the philosophy of Immanuel Kant. In his *Critique of Pure Reason*, Kant identifies dialectic as a part of the hierarchy of reason (Figure 1).

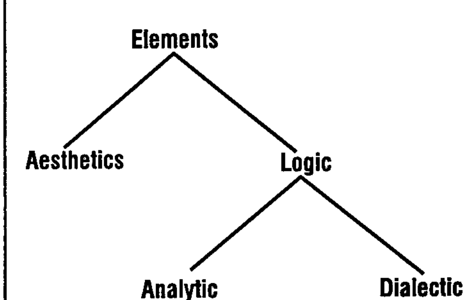



**Figure 1. Kant's Hierarchy of Reason**

**Captain David L. Peeler, Jr.**, is currently assigned to Hanscom Air Force Base, Massachusetts, where he serves as a Weapon Systems Cost Analyst. He was selected as HQ AFSPC's Financial Services Officer of the Year for fiscal year 1994 and was named the 341st Missile Wing's Company Grade Officer of the Year for 1994. He earned a Master of Science degree in Cost Analysis from the Air Force Institute of Technology in 1996. He is a Certified Cost Analyst and a Certified Acquisition Professional, Financial Management–Level I.

Kant's aesthetics involves the senses while logic encompasses intellect; the further division of logic—into analytic and dialectic—is concerned with understanding and refined reasoning, respectively (Bennett, 1974). The aesthetics have minimal, direct influence on the dialectic but play a role in the overall "scheme of things." The analytic addresses actually agreed upon "fact"—Karl Popper notwithstanding.[1] For example, water freezes at 32°F; the molecular structure of water is $H_2O$. Argument about these "facts" is vacuous because it is determined by observation. Dialectic isn't established by experiment or observation, but through the negativism of ideas (Weaver, 1953):

> ...we can therefore say that a dialectical position is established when its relation to an opposite has been made clear and it is thus rationally rather than empirically sustained.

The actuality is not what "dialectic secures for any position...but possibility..." (Weaver, 1953). The analytic represents the actual; this is determined by examination. The dialectic is more elusive; while the analytic addresses agreed-upon facts, dialectic deals with the realm of interacting possibilities available for deriving solutions to a problem.

Hegel built his system upon Kant's concept. Hegel maintained that dialectic has a negative character which "constitutes the genuine dialectical procedure" (Hegel, 1929). This "...negativity is manifest in the very process of reality, so that nothing that exists is true in its given form. Every single thing has to evolve new conditions and forms if it is to fulfill its potentialities" (Marcuse, 1954). The negative is manifested as the antagonist of the positive in a given solution—the positive being the existing proposition or idea. The negative acts as the devil's advocate in the proposed solution. The notion of dialectic therefore cannot be put in a single, correct proposition that has a claim to the essence of the problem or its solution.

No one approach to a problem exists, but solutions are governed by the creative power of contradiction. These contradictions or conflicts of ideas are intertwined in the process of reaching a solution. The conflict is no longer between opposing forces but becomes one between antagonistic forms of reality that coexist (Marcuse, 1954). Using Hegel's concept of triadic development, the dialectic forms the essence of the debate. This form is represented in its simplest state in Figure 2.

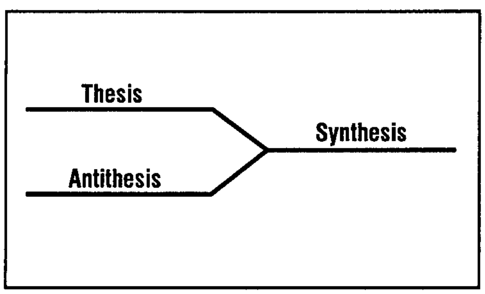



**Figure 2. Hegel's Simple Dialectic**

The thesis is contradicted (negated) by an antithesis with the ensuing conflict between the two producing a higher level (improved) concept, the synthesis. The positive (thesis) is opposed by the negative (antithesis), producing a superior synthesis. The best of both the positive and the negative form an improved idea. In a more complicated view, the synthesis becomes the thesis and the iterative process continues to evolve (Figure 3). The pro-

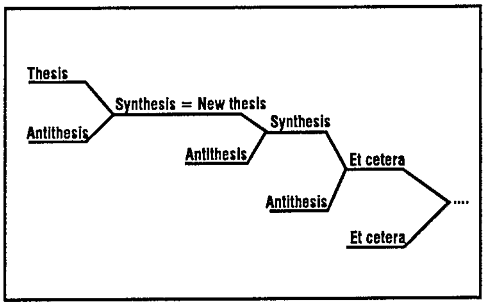



**Figure 3. More Complicated View of Hegel's Dialectic**

cess becomes even more complex with more than one simultaneous antitheses (Figure 4).

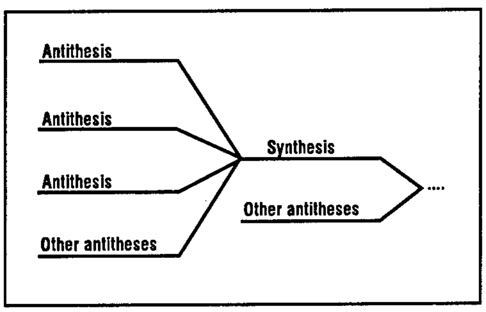



**Figure 4. Complex: Simultaneous Antitheses**

The evolution of this process is relevant to acquisition strategy. As one strategy component is proposed, others vie for predominance. The conflict of ideas throughout the acquisition strategy process is a dialectical exercise.

Practical application of the laws of reason (dialectic) are inherent in the evolution of the general development of an acquisition strategy. This evolution occurs through an iterative process to create a increasingly effective strategy. The iterative incorporation and integration of coexistent, alternative approaches produce a new synthesis. Each synthesis is met with opposing forces that perpetuate further syntheses, thus improving the acquisition process.

The theoretical laws of reason as summarized above are applicable to all aspects of an acquisition strategy. Dialectic is present in the give and take between DoD and Congress. "Every new solution presents a whole new set of problems" (L'Heureux and Grant, 1996). Each problem must evolve through the dialectical process to arrive at a viable, successful acquisition.

Acquisition policy, external environment, and program-specific factors are the three strata of acquisition strategy diagrammed in the text. All three of these make use of dialectical facets, involving choices that must be broken down, as expressed by Socrates, and dealt with in order to continuously improve the outcome of the process. Policy is established through the give and take of conflicting ideas. Formulation of policy, the definition of its criteria, and the development of a strategy are nothing more than choices between the best component parts articulated by the participants. Each thesis yields to the superior ideas included in its antithesis. The resulting synthesis is composed of the *best* of the opposing postulates.

Included within an acquisition strategy's external environment are the complex aspects of congressional oversight, exploitation of technology, existence of an industrial base, joint and international strategies, and strategies for competition (L'Heureux and Grant, 1996). All these, save the latter, are subject to the same coexistence of competing ideas that drive the resultant solutions; each are made up of conflicting proposals that contain good and less than... components.

The best aspects are taken from each proposal. Competition is less a factor of dialectic and more of an analogous concept. The concept of Adam Smith's "invisible hand" refers to the competition between alternatives with the result being a better solution. Economic competition thus becomes somewhat synonymous with dialectic; they have the same essence. However, this essence isn't as easily manifested in major weapon system or automated information system acquisitions.

The essence of competition involves an environment with relatively few rules and regulations; easy entry and exit into the marketplace, a large number of firms, a homogeneous product, and complete information concerning prices, quality, and production. The market surrounding weapons system (or any major government systems) acquisition does not fit the competition model. Our marketplace can be regarded as a monopsony (one buyer) purchasing from a duopoly (two or few sellers).[2] Therefore, the essence of dialectic is not obvious in acquisition contract competition. However, dialectic in the acquisition process, from conception to realization, is essential for the evolution of improved systems. This continuous improvement allows for the optimization of resources and mission performance capability.

The specific factors involved in an acquisition strategy program are all subject to the reasoning process—the dialectic. These factors include the master program; contracting, manufacturing, supportability, test and evaluation, and "high gear" program strategies; commercial off-the-shelf (COTS) and nondevelopmental items (NDI); and risk assessment (L'Heureux and Grant, 1996). Each of these factors involve the application of dialectic, showing that the laws of reason are at work *within* the structure of an acquisition strategy as well as at the upper echelons of policy formulation. The PM becomes a dialectician on two levels: He is the arbitrator between the masses within the program, determining which aspects of competing ideas to incorporate, and he becomes the program's advocate vis-à-vis the "philosophers" or between them. The PM must defend the program as it is placed in competition with others. He *must* become an advocate in order to ensure that the best pieces of each program are advanced and synthesized into the overarching framework of providing the strongest possible national security.

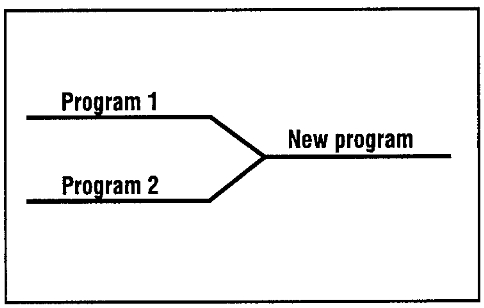



**Figure 5. Program Dialectic**

The PM must be cognizant of the fact that his program has good aspects that improve the outcome of the competition.[3] If he immediately sacrifices his program when faced with resource reductions, the function of dialectic is frustrated. Beneficial ideas will be lost that would otherwise survive to flourish in the resultant, synthesis program. If the PM doesn't fight for the program, the defense of the nation suffers. This truism is likewise applicable for those working on the program. They must defend their ideas for the program in order to improve it.

The acquisition strategy process is a functionally operating, continuous evolution of thesis, antithesis, and synthesis. Once each conflict has been resolved into a synthesis, a new antithesis emerges. So the process continuously generates improved options for the solution of a problem. The iterative evolution occurs through dialectic. The dialectic process places potential solutions into conflict, producing an improved combination of options or approaches used to achieve the desired objectives of a program within specified resource constraints. If every PM becomes an effective and active dialectician rather than a *de facto* one, the theoretical aspects of dialectics will improve the practical application and execution of acquisition strategy.

## REFERENCES

Aristotle. (1987). Topics. W. D. Ross (Trans.). Chicago: Encyclopaedia Britannica (104b). (Original work dates from 370 B.C.)

Bennett, J. (1974). Kant's dialectic. Cambridge, U.K.: Cambridge University Press (p. 1).

Hegel, G. W. F. (1929). The science of logic (W. H. Johnston & J. G. Struthers, Trans.) (p. 66). New York: Macmillan.

L'Heureux, R. Z., & Grant, K. P. (Eds.) (1996). Defense acquisition strategy: Development & execution (pp. 9–15). Unpublished text used at the Air Force Institute of Technology, Air University, Air Education and Training Command, Wright-Patterson Air Force Base, Dayton OH.

Marcuse, H. (1954). Reason and revolution: Hegel and the rise of social theory (pp. 123, 150). New York, Humanities Press.

Plato. (1937). Phaedrus. In B. Jowett (Trans.) The dialogues of Plato (265a). New York: Random House. (Original dates from 350 B.C.)

Weaver, R. (1953). The ethics of rhetoric (p. 27). South Bend, IN.: Regnery/Gateway.

## END NOTES

1. Karl Popper maintained that the verification of universal scientific statements is impossible. Verification would require confirmation of all instances through time and universe. The scientific method cannot accommodate this verification process; therefore, we seek falsifying instances that provide one example that the statement is not universal. Kant's analytic suggests that observation connotes fact. Popper would insist that simple observation does not prove scientific universality (*i.e., the speed of light in a vacuum or the freezing point of water.*

2. Although the evolving acquisition process now emphasizes the use of commercial off-the-shelf (COTS) products, for which there are multiple manufacturers, contracts are still awarded as before. Lacking the necessary expertise to integrate the various components that make up a system, the government contracts with one firm to perform this function. The number of firms capable of performing the integration function is, if anything (with the current rate of mergers and buyouts), diminishing. Therefore, the monopsony/duopoly relationship between the government and contractors continues to hold as acquisition methods evolve. COTS products are procured through prime contractors, of which there are relatively few for each acquisition area, who integrate the system and "load" the price.

3. The natural tendency of a reader is to surmise that the chosen example program is sufficiently dissimilar to his to exclude use of the example's processes. But, the dialectic is generic and applies to all processes and projects. A specific program is not discussed here to eliminate the tendency of readers to discount the premises because this or that element wasn't or isn't present in his program. The process of debate over aspects present in any program is what a program manager needs to contemplate, not the analogous nature of a particular program to the example.

# COMMERCIAL BEST PRACTICES AND THE DOD ACQUISITION PROCESS

*James S. B. Chew*

Continuous improvement continues to be the rallying point for Department of Defense (DoD) acquisition reform. The recent changes to the DoD 5000 show that the department is streamlining the acquisition process to meet the realities of the evolving "new world" threats. As dramatic as the changes have been, there is room for improvement. Here we compare the streamlined DoD acquisition process with the process used in the American automobile industry—which continually deals with an ever-evolving threat. We discuss the Chrysler Corporation product development process and identify the "best practices" in their product development process. These best practices can be applied to the DoD acquisition process.[1]

The basic tenets of the current Department of Defense (DoD) acquisition reform are "better, faster, cheaper." The acquisition reforms have resulted in a new DoD 5000 rule which dictates what should be performed during a major system acquisition, not how to perform one. Using the new 5000, the systems developed should be:

1. Better. A high-quality system must be designed and built right the first time.

2. Cheaper. The costs of developing, building, fielding, and maintaining the system are constrained more so than in the past.

3. Faster. The streamlined process reduces the amount of time required to acquire and properly field systems.

The idea of DoD acquisition reform is not new. Since the DoD 5000 was first issued in 1971, there have been nine revisions in an effort to streamline and fine tune the DoD acquisition process (Ferrara, 1996) Table 1 presents a summary of the revisions and changes to the DoD 5000 since it was issued.

Even with the latest significant acquisition reforms, there is room for improvement. By examining a commercial product development process, one can identify some "best practices" to further improve the DoD acquisition process.

## Commercial Acquisition Process

Market pressures have forced U.S. industries to change their product development (system acquisition) process to produce products in a "better, faster, cheaper" manner, or risk extinction. The American automobile industry is a good example because of the rapid change in threat (e.g., the rise of the Japanese automobile industry in the early 1980s). Chrysler Corporation, in particular, evolved unique responses to this threat. *Forbes* magazine named the corporation 1997 "Company of the Year" because of their response strategy (Flint, 1977).

Faced with the possibility of bankruptcy because their product was noncompetitive, Chrysler studied the Japanese automakers and developed their own product development process to significantly reduce the concept-to-production timeline. In addition to reducing the product development time from 60 to 30 months, the product requirements process was refined to ensure that the customer was "delighted" with the resulting product (Roush, 1996).

The Chrysler Product Development and DoD acquisition process timeline are compared in Figure 1. The similarities are surprising, with the one exception—their program time is 24 to 36 months versus DoD's 7 to 12 years.

## Commercial "Best Practices": The Chrysler Model

Chrysler has launched about 30 new products since 1991 using the process shown in Figure 1 (Chrysler, 1995). Sales, market share, customer satisfaction, customer loyalty, corporate profits, and dealer profits have all significantly increased during that time. In fact, the Chrysler product development process is now being studied by Japanese and European automakers.

Key elements of this process allowed Chrysler to achieve its goals of offering world-class, leading-edge products in a timely, competitive manner. These "best practices" which follow, should be considered for inclusion into any future DoD acquisition reform initiatives.

**Mr. Chew** has 13 years of experience in rocket propulsion, space system and weapons technology development, and technology acquisition. He holds a B.S. degree in mechanical engineering from California State Polytechnic University, Pomona, and an M.S. degree in systems management from the University of Southern California. He is a graduate of the Defense Systems Management College Advanced Program Management Course 96-2. Chew received the 1991 Air Force Systems Command Science and Technology Achievement Award. Chew was a propulsion engineer at Boeing Aerospace, a senior propulsion engineer at SPARTA, and became Chief, Rocket Propulsion Technology, Plans and Programs Directorate, at the Air Force Phillips Laboratory (formerly the Air Force Rocket Propulsion Laboratory and Air Force Astronautics Laboratory). He was assigned to the Office of the Director, Defense Research and Engineering, as a staff specialist (conventional weapons), from 1994–96. He is currently program manager, Naval Air and Surface Weapons Technology, Office of Naval Research. In addition, he is a product marketing consultant for Chrysler's Dodge Division, and is an adjunct engineering professor at Antelope Valley College.

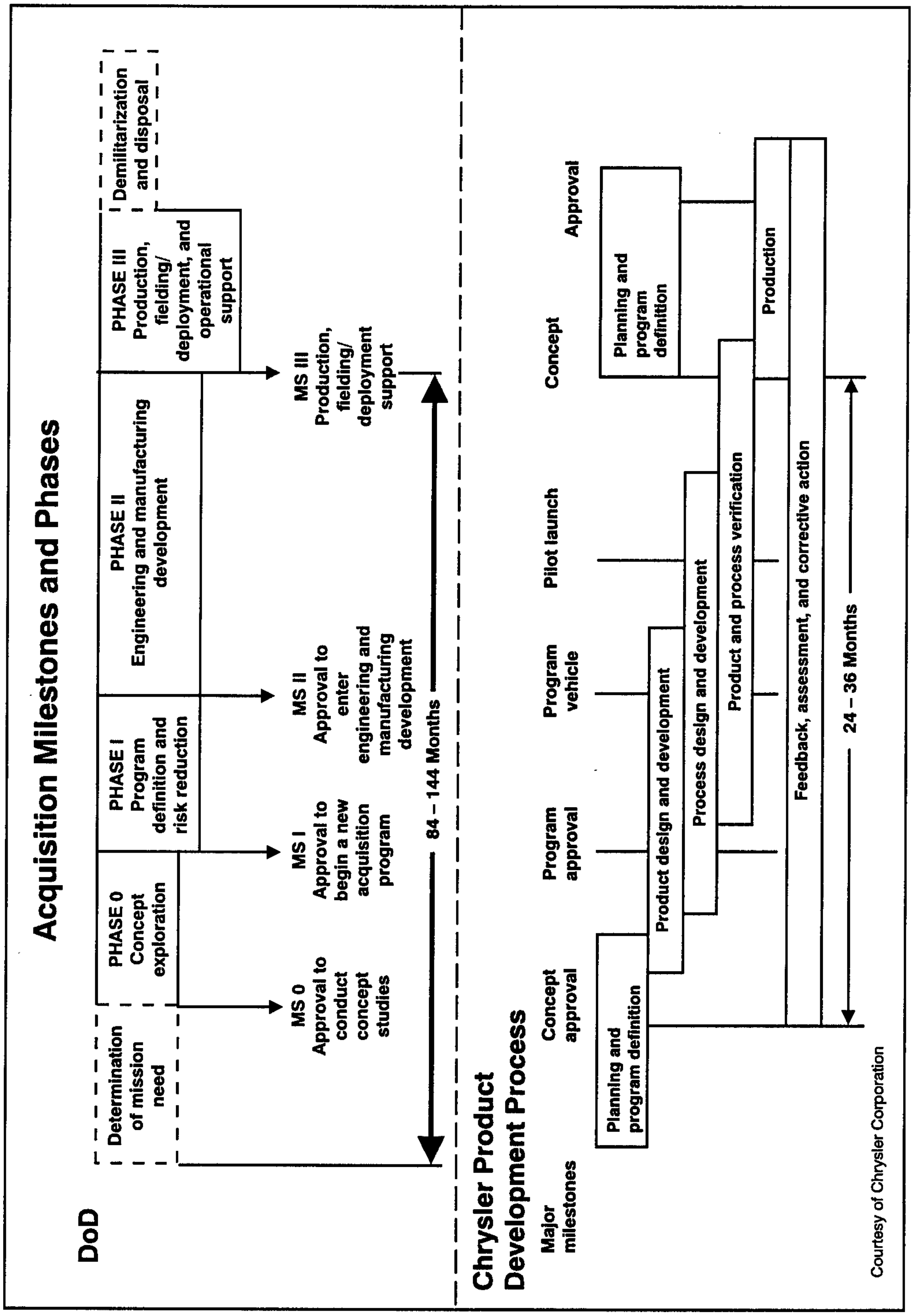



**Figure 1. Comparison of DoD Acquisition Timeline to Chrysler Product Development Timeline**

### Continuous Improvement

Although the Chrysler product development process has been proven, the process is updated and refined with every new product, and thus incorporates the lessons learned from the previous development.

### Requirements Benchmarking

The requirements for each new product are developed through aggressive benchmarking, performed both inside and outside of the company. In external benchmarking, prospective customers are surveyed to determine what they want in a certain product. This is performed through product clinics and focus groups: prospective customers are brought to a central location and surveyed about their likes, dislikes, and desires concerning certain competitive products. They are then shown several future product concepts to determine what features should be incorporated into it. The external benchmarking yields a rearview mirror perspective of system requirements. The customers can only tell the designer what they like based on the available choices.

**"Past performance has shown that the cross-functional process, team member empowerment, and the desire for continuous improvement have reduced the development cycle time for each new product."**

The internal benchmarking, on the other hand, is performed to provide the *vision* of what the future products should be. It is performed by the employees studying and testing the competition to determine the "best in class" attributes. Based on known customer desires, quality function deployment exercises to determine the key elements of customer desires, and monitoring of future automotive technology trends, management develops projections of what these attributes would most likely be by the time the developed product is launched as well as through the life cycle of that product. Through aggressive benchmarking and continued efforts to reduce product development cycle time, Chrylser is able to challenge yet achievable product requirements that make the developed product best in its class at launch and keep it competitive until a new model is fielded.

### Cross-Functional Platform Teams

Chrysler established product development "platform" (e.g., small car, large car, minivan, Jeep–truck) teams that incorporate all the disciplines necessary to develop a product, including engineering, manufacturing, sales, marketing, and finance. The platform team leader is given a product development budget, which cannot be exceeded. The team leader is allowed to shift costs when the team feels it is appropriate, but the product development schedule must be maintained. The platform team leader uses consensus techniques to make decisions with the understanding that once decisions are made, the entire platform team supports them. Past performance has shown that the cross-functional process, team member empowerment, and the desire for continuous improvement have reduced the development cycle time for each new product.

### Independent, Aggressive Advanced Concept Development

To meet future product requirements and market conditions, Chrysler estab-

lished an independent advanced product development platform team that develops conceptual vehicles that meet time-phased technology goals five to ten years into the future. During the development of these advanced concept vehicles, the engineers and designers identify technologies, processes, and components that require development. The advanced concept engineers and designers write technical memorandums to the other platform development teams that outline (a) the technology, component, or process they have developed; (b) when it will be ready for incorporation into a production vehicle; (c) the competitive advantage of the technology, component, or process; and (d) techniques for incorporating that technology, process, or component.

This advanced concept development team, known as Chrysler Liberty, is located separate from the rest of the platform development teams. Customer reaction to these technologies and design concepts is gauged by showcasing advanced concept vehicles at the annual major auto shows (Moore, 1997).

### Program Stability

At the concept approval phase, the corporate officers and the platform team leader agree to a "contract" in which the corporate officers approve a product development budget and schedule and the platform team leader agrees to produce, field, and establish the required logistics and operational support for a product that meets the established requirements. During product development, the budget remains stable and the product requirements are changed only if the competition surprises the platform development team. However, all changes are performed by the team. The corporate officers are briefed on the progress of the work.

### Addressing Product Quality Upfront and Early

The automobile manufacturers and their supplier base are striving to work toward the ISO 9000 quality and reliability standard. However, ISO 9000 specifies what is expected of a quality system, not "how" to establish a quality system. Figure 2 presents the detailed tasks that dictate the how for the concept phase of the Chrysler product development process (Roush, 1996). This phase takes place *prior* to concept approval. Note the number of quality and reliability tasks that are performed during this phase. The number of quality and reliability tasks, including product serviceability and assembly, significantly increase with each product development phase. These quality and reliability tasks are required of Chryler's supplier base also (Lesniack, 1996). Suppliers are graded on their component quality and reliability; Chrysler does help suppliers that are having problems in these areas.

Because an assembly line shutdown for any reason costs the manufacturer approximately $3,000 a minute, it behooves both the manufacturer and the supplier to ensure that quality components are delivered to that line on time. Chrysler has found that "design for manufacturing" issues, such as design of experiments to identify the manufacturing variables and manufacturing lessons learned from previous products, must be identified and addressed during the concept development phase. This avoids the use of components or assembly procedures that require unique processes. Not only does this help

ensure high product and component quality, but ultimately lowers the cost of product development by eliminating costly redesigns and manufacturing processes. By addressing quality and reliability *aggressively and early* in product development, the need for material review boards to address noncompliant component issues are significantly reduced.

## APPLYING COMMERCIAL "BEST PRACTICES" TO DOD ACQUISITION

Applying some or all of these commercial best practices to the DoD acquisition process would decrease the acquisition costs and timeline as well as significantly improve the quality and reliability of the delivered system. But, each of these practices has an impact; we will now discuss some of them.

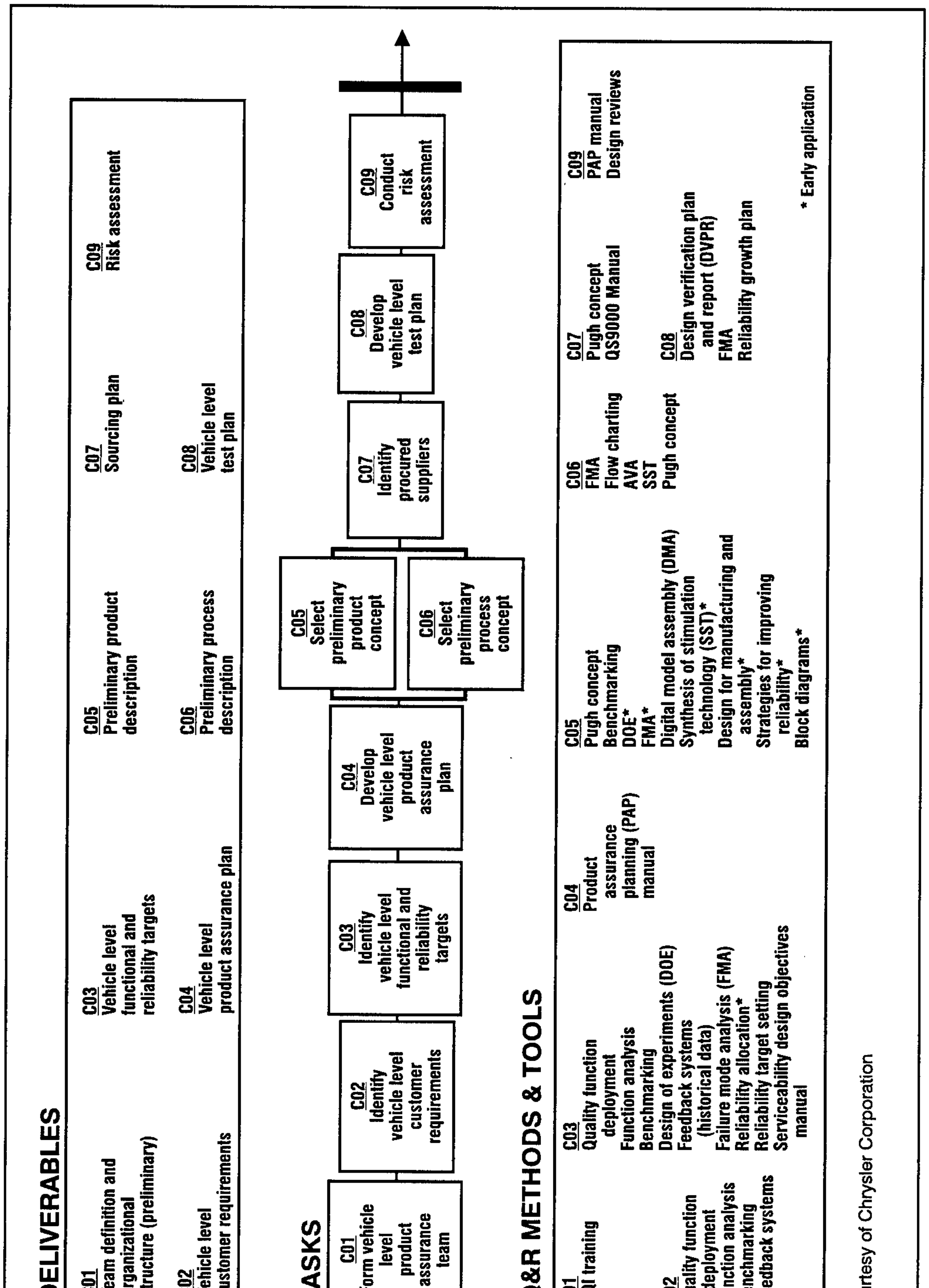
### CONTINUOUS IMPROVEMENT

The basis for following the Chrysler product development continuous improvement philosophy is the establishment of a process baseline. This baseline should identify and discuss in detail the significant tasks that must be performed during each phase. The expected "deliverables" for each milestone should also be identified and discussed. The tasks and deliverables may be modified, eliminated, or added as a result of "lessons learned." Using such a manual, with lessons learned from previous programs incorporated, program managers for new acquisition category (ACAT 1) programs, such as the Joint Air-to-Surface Standoff Missile (JASSM), the Joint Strike Fighter (JSF), the Evolved Expendable Launch Vehicle (EELV), and the Surface Combatant-21 (SC-21), would develop an initial program acquisition flowchart, with detailed tasks. The government–industry team would modify or revise them as the programs progress though Milestone III, and the charts would become the basis for an ACAT 1 program acquisition manual. Subsequent ACAT 1 programs would modify the manual as their "lessons learned" accrued.

**"Too often in the past, coordination with the science and technology community did not occur until well after Milestone 0."**

### REQUIREMENTS BENCHMARKING

The two major parties that need to work closely with the weapons designers during the requirements benchmarking process are the product customer (i.e. the warfighter, which includes the operations, maintenance, and logistics communities, and major operational commands) and the DoD science and technology community. The product customer helps the designer identify the deficiencies with the current systems and the needs that they would like a new system to fulfill. The DoD science and technology community, through a focused, time-phased, goal-oriented program, helps the designer identify the level of technology that will be available for the proposed new system. By combining the customer comments and the science and technology available, prototype systems on either the component, subcomponent, or "virtual" level would be developed and used for customer product "clinics." The weapons designer would use the data and information from both groups and the clin-




Courtesy of Chrysler Corporation

**Figure 2. Product Assurance Planning: Concept Phase**

ics to project what requirements the new system would need in order to be a "benchmark" system when fielded, and continue to be extremely competitive through its life cycle. Once these system requirements are set, they should not be changed or modified during the program acquisition. This step needs to be performed prior to Milestone 0. Too often in the past, coordination with the science and technology community did not occur until well after Milestone 0.

### Cross-Functional Platform Teams

As is the Integrated Product Team (IPT), the cross-functional platform team would be developed "upfront and early" in the program (prior to Milestone 0). As with Chrysler, the relevant industrial base would be brought in to provide a realistic determination of technology readiness and costs. These teams would be responsible for either developing or modifying their program acquisition flowchart and manual.

### Independent, Aggressive Advanced Concept Development

To provide focus for the DoD science and technology community and provide ideas for future weapon systems designers and customers, more advanced concept demonstrations would need to be conducted as part of the DoD science and technology program. In addition to providing *focus* to the DoD labs and the industrial base, these hardware demonstrations provide a mechanism to address quality and reliability issues of incorporating the new technology "upfront and early," and provide an opportunity for the weapons designer to address technology transition and integration issues.

The DoD science and technology program would become even more efficient through these technology demonstrations, providing the program had time-phased technology goals that would be used consistently for these demonstrations. Existing DoD science and technology projects such as the Integrated High Performance Turbine Engine Technology (IHPTET) program and the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program have already developed time-phased technology goals, which will be demonstrated to help provide the weapons designer with propulsion system design options for future systems.

### Program Stability

Program stability requires both requirements stability, which should be addressed through aggressive requirements benchmarking, and resource allocation process reform (Planning, Programming, Budget, Scheduling and Congressional Budget enactment) (Moore, 1997). The focus of this reform effort would be to *not* require annual acquisition program justifications, and to provide the acquisition program manager with the entire required program budget at Milestone 1 and allow the program manager to manage that budget through the course of that program. Concepts such as two-year appropriations and multi-year procurement would help provide program stability. The ability to commit future Congressional appropriations as well as trust in the acquisition program manager is necessary to provide the necessary program stability.

### Addressing Product Quality Up-Front and Early

Most of the DoD ACAT 1 programs are addressing the "cost of quality" issue (Lesniack, 1996). The cost savings projected by some of these programs, the Evolved Expendable Launch Vehicle (EELV) in particular, are from significant reductions in the cost of quality. The EELV program is using a "no-MRB" (Materials Review Board) strategy, which puts the quality burden primarily on the contractor. This implies applying the various quality design techniques during the *concept exploration phase,* which requires more funding at the beginning of the program. The acquisition program does not require more funding overall, just more up front. In fact, the Japanese have shown that applying more funding at the beginning of a product development program can actually reduce program costs and schedule. This is very much in keeping with the maxim, "an ounce of prevention is worth a pound of cure." The major impact is that instead of funding several small system development concept contracts with "seed money," the DoD and industry will need to do more work together, through contractual vehicles, to include more manufacturing and technology risk reduction during Phase 0. This will be most effective when combined with aggressive requirements benchmarking and program stability.

### Summary

It should be noted that these "best practices" used by the Chrysler Corporation were developed as a result of the Chrysler Corporate Officers realization that the way they were conducting business would result in their bankruptcy. A corporate culture to "reinvent" the company to be the best automaker in the world was "brought in" by the entire company, and the product development process they now use is a result of this effort. By using their process, Chrysler has not only reduced their product development time from 60 to 24 months, but they have significantly reduced product development costs. Key to this transition was the willingness of the company to experience short term setbacks during the "re-invention period" for the significant long term gains.

The DoD is in a similar situation—the way we are doing business does not fit with the new world realities. While the current DoD Acquisition Reforms have been applauded by industry leaders, there is an acknowledgment that they do not go far enough (Augustine, 1996). Shorter system development cycle times, aggressive future system benchmarking initiatives, and focused, aggressive advanced concept development efforts are practices which would serve to keep DoD systems and the industrial base on the "leading edge." Although applying the aforementioned commerical "best practices" may not be "the" acquisition reform answer that many in the defense industry desire, it will go a long way toward meeting that goal.

| YEAR | MAJOR CHANGES | REASONS | MAJOR MILESTONE | FORMAL MILESTONE DOCUMENT |
|---|---|---|---|---|
| 1971 | | • Demonstrating to Congress a credible management system<br>• Responding to Vietnam era drawdown | • Program initiation<br>• Full-scale development<br>• Production and deployment | • Decision coordination paper (DCP) |
| 1975 | • Minimal changes to 5000.1<br>• Included references to 19 DoDDs and DoDIs | • New administration<br>• Issuance on new DoDI 5000.2 | • Program initiation<br>• Full-scale development<br>• Production and deployment | • DCP |
| 1977 | • DSARC charter included in 5000.2<br>• Both documents issued as DoDDs<br>• Added dem/val milestone<br>• Directed establishment of service<br>• Added definitions section | • Implement OMTBV A-109 | • Program initiation<br>• Full-scale development<br>• Production and deployment | • Mission element need statement (MENS—for MISO)<br>• DCP |
| 1980 | • Separate discussion of affordability, acquisition time, and tailoring<br>• Added new milestone documentation and included administrative details such as a pre-DSARC countdown<br>• Called out "Secretary of Defense decision memorandum" as official document | • Change of administration<br>• Emphasize need to reduce cycle time and to correlate acquisition decision with PPBs | • Program Initiation<br>• Demo/Eval<br>• Full Scale Development<br>• Production & Development | • MENS<br>• DCP<br>• Integrated program summary |

**Table 1. The 500 Series Historical Perspective**

| YEAR | MAJOR CHANGES | REASONS | MAJOR MILESTONE | FORMAL MILESTONE DOCUMENT |
|---|---|---|---|---|
| 1982 | • More explicit language on program stability, Economic production rates, and evolutionary acquisition strategies<br>• Justification for major systems new starts replaces MENS | • Change of administration<br>• Implement Carlucci initiatives and Defense Acquisition Improvement Program | • Program initation<br>• Dem Val<br>• Full-scale development<br>• Production and deployment (delegated to components) | • JMSNS<br>• System concept paper (SCP)<br>• Test and evaluation master plan<br>• DCP<br>• IPS |
| 1985 | • Named Deputy Secretary as "Defense Acquisition Executive"<br>• Reflected new ASD (Acquisition and Logistics) as Milestone III DSARC chair | • Demonstrate that top officials were paying attention to acquisiiton system<br>• Respond to procurement horror stories | • Same as 1982 | • Same as 1982 |
| 1986 | • Includes discussion of DOT&E as member of DSARC<br>• Includes discussion of content and timing of the beyond low rate initial production reports (B-LRIP) | • Reflect establishment of new Director of Operations Test and Evaluation (DOT&E) and associated reporting requirements | • Same as 1982 | • Same as 1982 plus the B-LRIP report |

**Table 1. The 500 Series Historical Perspective (continued)**

| YEAR | MAJOR CHANGES | REASONS | MAJOR MILESTONE | FORMAL MILESTONE DOCUMENT |
| --- | --- | --- | --- | --- |
| 1987 | • Includes discussion of USD(A)<br>• Breaks major programs into two categories: DAB and component<br>Includes discussion of program baseline | • Implement Packard Commission and related acquisition improvement legislation<br>• Reflect establishment of new Under Secretary of Defense for Acquisition<br>• Emphasize that 5000 acquisition policies apply department-wide | • Milestone 0, Concept Exploration and Definition<br>• Milestone I, Demonstration and Validation<br>• Milestone II, Full Scale Development/Low Rate Initial Production<br>• Milestone III, Full Rate Production and Initial Deployment<br>• Milestone IV, Review Readiness and Support<br>• Milestone V, Upgrade or Other Replacement Action | • Mission Need Statement<br>• Cooperative Opportunities Document<br>• System Concept Paper<br>• Test and Evaluation Master Plan<br>• Cost and Operation Effectiveness Analysis<br>• Common-Use Alternatives Statement<br>• Program Baseline<br>• Independent Cost Estimate<br>• Decision Coordinating Paper<br>• Acquisition Strategy Report<br>• Beyond-LRIP Report<br>• Manpower Estimate Report |
| 1991 | • Consolidation of more than 50 directives, instructions, and policy memoranda into a unified set of acquisition guidance<br>• Application of 5000.2 procedures to all acquisition category programs<br>• Creation of a manual specifying detailed formats and procedures for acquisition reports | • Change of administration<br>• Implement Defense Management Report | Same as 1987 except for deletion of Milestone V | Same as 1987 except for:<br>• Several documents formerly treated in separate regulations, such as Operational Requirements Document and System Threat Assessment Report, were now discussed in the new 5000.2-M manual<br>• The SCP, DCP, and common-use alternatives statement were deleted |

**Table 1. The 500 Series Historical Perspective (continued)**

| YEAR | MAJOR CHANGES | REASONS | MAJOR MILESTONE | FORMAL MILESTONE DOCUMENT |
|---|---|---|---|---|
| 1996 | • Deletion of substantial volume of guidance formerly treated as mandatory<br>• New guiding principles on non-traditional acquisition, IPPD, and innovative practices<br>• Institutionalization of IPTs and IPPD<br>• Deletion of numerous report formats | • Institutionalize reform efforts<br>• Implement reinventing government initiatives<br>• Integrate policy for weapon systems and automated information systems | Same as 1987 except for:<br>• Deletion of Milestone V<br>• Treatment of LRIP as a separate decision point that may be held after the Milestone II decision | Same as 1991 with the following changes:<br>• Mandatory formats only specified for CARFS, ORD, TEMP, LFT&E, MAID quarterly report |

**Table 1. The 500 Series Historical Perspective (continued)**

## REFERENCES

Augustine, N. (interview, President and CEO, Lockheed Martin, Nov. 4, 1996).

Bradley, R. (interview, Secretary of the Air Force for Acquisition, Sept. 15, 1996).

Chrysler Corporation. Product assurance planning manual (2nd ed.).

Ferrara, J. (1996). DoD's 5000 documents: Evolution and change in defense acquisition policy. Journal of the Defense Acquisition University, 3 (2).

Flint, J. (1997, Jan. 13). Company of the year: Chrysler has the hot cars. More important, it has a smart, disciplined management team. Forbes.

Lesniack, E. (interview, Large Car Platform Product and Supplier Quality, Chrysler Corporation, Oct. 14, 1996).

Moore, T. (interview, General Manager, Liberty Product Development, Chrysler Corporation, Jan. 31, 1997).

Roush, R. (interview, Director, Platform Quality, Chrysler Corporation, Oct. 14, 1996).

Singley, G. (interview, Deputy Director, Defense Research and Engineer, Nov. 8, 1996).

**ACKNOWLEGMENT**

This work was performed as an Individual Learning Project during the DSMC APMC 96-2 class. The author wishes to thank Professor W. W. Bahnmaier for his assistance and guidance.

# ACQUISITION REVIEW QUARTERLY GUIDELINES FOR CONTRIBUTORS

The *Acquisition Review Quarterly (ARQ)* is a scholarly peer-reviewed journal published by the Defense Acquisition University. All submissions receive a masked review to ensure impartial evaluation.

## Submissions

Submissions are welcomed from anyone involved in the Defense acquisition process. Defense acquisition is defined as the conceptualization, initiation, design, development, test, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services to satisfy Defense Department needs, or intended for use in support of military missions.

## Research Articles

Manuscripts should reflect research or empirically-supported experience in one or more of the aforementioned areas of acquisition. Research or tutorial articles should not exceed 4,500 words. Opinion pieces should be limited to 1,500 words.

We publish Defense Acquisition research articles that involve systemic inquiry into a significant research question. The article must produce a new or revised theory of interest to the acquisition community. You must use a reliable, valid instrument to provide your measured outcomes.

## Manuscript Sections

The introduction should state the purpose of the article and concisely summarize the rationale for the undertaking.

The methods section should include a detailed methodology that clearly describes work performed. Although it is appropriate to refer to previous publications in this section, the author should provide enough information so that the experienced reader need not read earlier works to gain understanding of the methodology.

The results section should concisely summarize findings of the research and follow the train of thought established in the methods section. This section should not refer to previous publications, but should be devoted solely to the current findings of the author.

The discussion section should emphasize the major findings of the study and its significance. Information presented in the aforementioned sections should not be repeated.

## Research Considerations

Contributors should also consider the following questions in reviewing their research-based articles prior to submission:

- Is the research question significant?
- Are research instruments reliable and valid?
- Are outcomes measured in a way clearly related to the variables under study?
- Does the research design fully and unambiguously test the hypothesis?
- Did you build needed controls into the study?

Contributors of research-based submissions are also reminded they should share any materials and methodology necessary to verify their conclusions.

## Criteria for Tutorials

Tutorials should provide special instruction or knowledge relevant to an area of defense acquisition to inform the Defense Acquisition Workforce.

Topics for submissions should rely on or be derived from observation or experiment, rather than theory. The submission should provide knowledge in a particular area for a particular purpose.

## Opinion Criteria

Opinion articles should reflect judgments based on the special knowledge of the expert. Opinion articles should be based on observable phenomena and presented in a factual manner; that is, submissions should imply detachment. The observation and judgment should not reflect the author's personal feelings or thoughts. Nevertheless, opinion pieces should clearly express a fresh point of view, rather than negatively criticize the view of another previous author.

## Manuscript Style

We will require you to recast your last version of the manuscript, especially citations (e.g., footnotes or endnotes) into the format required in two specific style manuals. The ARQ follows the author (date) form of citation. We expect you to use the Publication Manual of the American Psychological Association (4th Edition), and the Chicago Manual of Style (14th Edition). The ARQ follows the author (date) form of citation.

Contributors are encouraged to seek the advice of a reference librarian in completing citations of government documents. Standard formulas of citations may give only incomplete information in reference to government works. Helpful guidance is also available in Garner, D.L. and Smith, D.H., 1993, The Complete Guide to Citing Government Documents: A Manual for Writers and Librarians (Rev. Ed.), Bethesda, MD: Congressional Information Service, Inc.

## Copyright Information

The ARQ is a publication of the United States Government and as such is not copyrighted. Contributors of copyrighted works and copyright holders of works for hire are strongly encouraged to request that a copyright notification be placed on their published work as a safeguard against unintentional infringement. The work of federal employees undertaken as part of their official duties is not subject to copyright.

In citing the work of others, it is the contributor's responsibility to obtain permission from a copyright holder if the proposed use exceeds the fair use provisions of the law (see U.S. Government Printing Office, 1994, Circular 92: Copyright Law of the United States of America, p. 15, Washington, DC: Author). Contributors will be required to submit a copy of the written permission to the editor before publication.

## Manuscript Format

Pages should be double-spaced and organized in the following order: title page, abstract, body, reference list, author's note (if any), and figures or tables. To ensure anonymity, each paper should be submitted with a separate page that includes the author(s)'s name(s) and complete address, and the paper should include the title, abstract, keywords, body, complete set of references, along with tables and figures at the end. Authors are reminded not to refer to themselves or to their own work directly in the paper. Figures or tables should not be inserted (or embedded, etc.) into the text, but segregated one to a page following the text. Articles must be printable within one issue and should not exceed 4,500 words for research or tutorials and 1,500 words for opinion pieces; articles will not be printed in parts or in a continuing series. If material is submitted on a computer diskette, each figure or table should be recorded in a separate, exportable file (i.e., a readable .eps file). For additional information on the preparation of figures or tables, see CBE Scientific Illustration Committee, 1988, Illustrating Science: Standards for Publication, Bethesda, MD: Council of Biology Editors, Inc. Please restructure briefing charts and slides to a look similar to those in previous issues of ARQ.

The author (or corresponding author in the case of multiple authorship) should attach to the manuscript a signed cover letter that provides the author's name, address, and telephone number (fax and Internet addresses are also appreciated). The letter should verify that the submission is an original product of the author; that it has not been published before; and that it is not under consideration by another publication. Details about the manuscript should also be included in this letter: for example, its title, word length, the need for copyright notification, the identification of copyrighted material for which permission must be obtained, a description of the computer application programs and file names used on enclosed diskettes, etc.

The letter, one copy of the printed manuscript, and any diskettes should be sturdily packaged and mailed to: Defense Systems Management College, Attn: DSMC Press (ARQ), 9820 Belvoir Road, Suite G38, Fort Belvoir, VA 22060-5565.

In most cases, the author will be notified that the submission has been received within 48 hours of its arrival. Following an initial review, submissions will be referred to referees and subsequent consideration by the ARQ Editorial Board.

Contributors may direct their questions to the Editor, ARQ, at the address shown above, by calling (703) 805-4290 (fax 805- 2917), or via the Internet at gonzalezd@dsmc.dsm.mil.

The DSMC Home Page can be accessed at:

http://www.dsmc.dsm.mil.

# LETTER TO THE EDITOR

Having recently read the Winter 1997 (Vol. 1, No. 4) edition of the *Acquisition Review Quarterly*, I wanted to write a letter to the authors of the article entitled "Rethinking Twenty-first Century Acquisition: Emerging Trends For Efficiency Ends."

The Department of Defense has operated various arrangements with industry for support and services for years. To make the topic of the so called "...three emerging public-sector trends—privatization, promotion of competition, and continuous process improvement..." appear to be in the vanguard of the twenty-first century is wrong.

The authors do not recognize nor discuss the fundamental question that each acquisition program must handle and make a decision: What should be the best support structure for the life of the equipment/program. It is not: What is the cheapest, or how does WAL-MART do it? When was the last time WAL-MART deployed? The glib use of metrics from the private sector may sound good, but the Department of Defense does not have stockowner value as its goal—it has the often fuzzy, always debatable concept of readiness to fight and win as its goal.

The decision to use a particular support structure for a given program has been based on such elements as lack of adequate resources in the program to political considerations at the local level. For the Program Manager or Acquisition Executive the "policy" decision is the degree of organic versus non-organic support. The factors impacting that policy decision range from economic to political, but if that initial policy decision isn't made, then the program flounders in different uncoordinated approaches and ends up costing much more than it should.

This is what is happening today. Because there is a lack of a disciplined, quantitative approach to the support structure policy decision, programs are placed under pressure to carve out areas for privatization and unequal competition between public and private sectors. The pressure to go "private" will increase as corporations see the market availability's shift from end items to life cycle support and maintenance. There has already been a shift away from competition among suppliers as original equipment manufacturers try to retain their market share and have stepped up their proprietary claims.

The conclusion of the authors, that the "...policy initiatives are sweeping public sector management..." and that "...program managers...must implement policies to improve efficiency or face the threat of privatization themselves" is the wrong signal and an erroneous conclusion. The acquisition community experts should be exploring methodologies to evaluate these different support structures, to take the discussion out of the political arena and into the unemotional field of quantitative analysis, to develop the metrics for determining the degree of organic versus nonorganic supports and to provide the decision maker with information needed to make informed, useful business decisions.

CAPT A. E. Steigelman, SC, USN
Arlington, VA

# AUTHOR RESPONSE TO LETTER TO THE EDITOR

We believe intellectual interchange is exactly what the Acquisition Review Quarterly is all about. Discussion, debate, and deliberation in the arena of ideas is welcomed to help advance general knowledge and in this case, our understanding and appreciation of acquisition in the 21st century. Offering our article, "Rethinking 21st Century Acquisition: Emerging Trends for Efficiency Ends" to the acquisition community provides just one perspective of what the future of acquisition may look like. We are enthused and thank Captain A.E. Steigelman for his comments and insights on our article.

Continuing the spirit and inquiry of Capt Steigelman's letter, we do however disagree with some of his remarks. First and foremost, our fundamental thesis is that as we know it today program managers and the major weapon system acquisition community are not immune from the possible elimination and replacement by the private sector. As such, we suggest the acquisition program manager should not only be aware of other efficiency improvement initiatives occurring in the federal government but be implementing them when possible where they make sense. This proposition is based on the current wave of apparently more efficient alternative approaches proposed by Congress, many Federal agencies, as well as the Executive branch. The countless, well-documented instances of privatization, outsourcing, and OMB Circular A-76 competitions literally choke the popular press, calling for the government to investigate alternative means to perform diverse functions such as the space program, depot maintenance, and base facility management. Is acquisition management so peculiar from these?

Secondly, our article does not focus on "what is cheapest" or "how Wal-Mart does it" as Capt Steigelman implies. In fact we agree with Capt Steigelman that there is an increasing emphasis on life cycle options and a search for metrics. We propose financial analysis and Activity Based Costing (ABC) as potential alternatives to measuring efficiency and cost basis, not as panaceas.

Third, we find it unrealistic to "...take the discussion out of the political arena and into the unemotional field of quantitative analysis..." as Capt Steigelman suggests. Those of us in the acquisition community do not have the luxury of ignoring the political environment, nor what other federal agencies are doing. As we reflect on the National Performance Review, the Commission on Role and Missions, the Defense Science Board, the GAO and many other entities, all are prodding the DOD to outsource and privatize more, not less.

Finally, regarding his question, "When was the last time Wal-Mart deployed?", we offer another question, "When was the last time Brown & Root Service Corporation deployed?" One finds the deployment history of this private sector business to include Somalia, Rwanda, Haiti, Southwest Asia, Bosnia and Croatia (AFJ, Oct

96 pp. 19-22). Granted we recognize certain functions will always be "inherently governmental" in nature. It is clear however if front line units are outsourcing and privatizing, the acquisition community should be aware of and investigating these emerging trends for efficiency ends.

Capt Steigelman's letter alludes to some very well-thought and documentable ideas and suggestions which we enjoyed reading. We suggest he continue with this line of thought and provide these suggestions to the acquisition community to build on the energy generated from this article and our dialogue. As this discussion shows, we all firmly believe we are in this together. The only people that are wrong in such a debate are people that think the system is working at peak efficiency and promote the status quo.

Conrad S. Ciccotello, Major, USAF
Steve G. Green, LTC, USAF
Martin J. Hornyak, Major, USAF

The *ARQ* welcomes Letters to the Editor, but retains the right to edit letters. All attempts will be made to honor original content and context as space permits. Send letters to:

Defense Systems Management College
ATTN: Debbie Gonzalez
9820 Belvoir Road, Ste. G38
Fort Belvoir, VA 22060-5565

or e-mail to:
gonzalezd@dsmc.dsm.mil.

# ERRATA

The *ARQ* would like to clarify an error made to the article entitled "A Holistic Management Framework for Software Acquisition," by Dr. Yacov Haimes, Dr. Richard Schoof, and Mr. Clyde Chittister. Dr. Schoof and Dr. Haimes' names were inadvertently switched. Dr. Schoof is the senior author, followed by Dr. Haimes and Mr. Chittister.

We would like to apologize to the authors of the article entitled "Development of Emerging Telemedicine Technologies within the Department of Defense." We inadvertently dropped Dean Calcagni's name as an author on the article's title page and omitted Timothy Cramer's biography.

# DSMC'S Home Page

## http://www.dsmc.dsm.mil

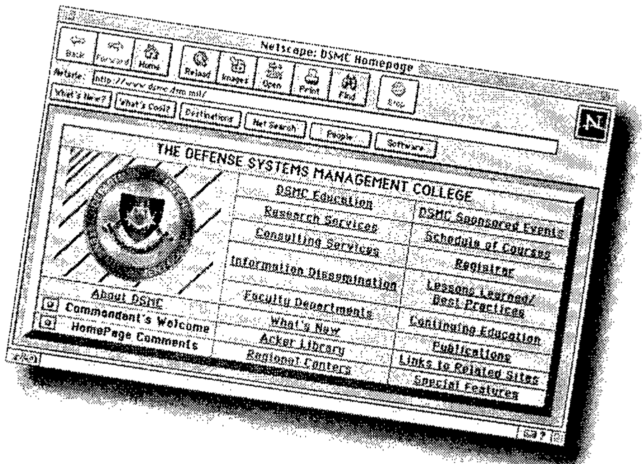
**Your Online Access to Acquisition Research, Consulting, Information, and Course Offerings**

### On DSMC Home Page Now

- About DSMC
- Commandant's Welcome
- HomePage Comments
- Executive Institute
- DSMC Education
- Research Services
- Consulting Services
- Information Dissemination
- Faculty Departments
- David D. Acker Library
- What's New
- Regional Centers
- DSMC Sponsored Events
- Schedule of Courses
- Registrar
- Lessons Learned / Best Practices
- Continuing Education
- Publications
- Links to Related Sites
- Special Features

### Links to Related Acquisition Sites

- ACQ Web (Office of the Under Secretary of Defense for Acquisition and Technology)
- Air Force Acquisition Home Page
- DoD Acquisition Workforce Home Page
- DoD Acquisition Workforce
- OSD Acquisition Program Integration
- ARNet - Acquisition Reform Net
- ALLCARS On-line link
- CRFPST - Centralized RFP Support Team Office
- Continuous Acquisition and Lifecycle Support (CALS)
- Commerce Business Daily
- Defense Acquisition Revolution
- Defense Acquisition Reform Initiatives
- Defense Acquisition University
- DefenseLINK
- Deskbook Joint Program Office
- DoD Deskbook
- DISA/JIEO Center for Standards
- Defense Technical Information Center (DTIC)
- DTIC - Information Technology "summIT"
- DTIC - Defense Science and Technology Planning Home Page
- DTIC - List of DoD Directives and Instructions
- Earned Value Management
- Hill Air Force Base and Ogden Air Logistics Center (FAR/DFAR)
- National Council on Acquisition Professionalism (NCAP)
- National Institute for Standards and Technology




- Navy Acquisition Reform
- Navy CALS
- Naval Air Warfare Center
- Past Performance Systems Report
- Product Acquisition and Engineering
- Project Management Forum
- Directory of Project Management Resources
- Featured Publications of the SEI
- Standards Management Groups

### Lessons Learned and Best Practices

- DSMC EVM Department - Integrated Baseline Review
- Air Force Acquisition Streamlining
- Air Force Material Command
- ARNET
- Center for Army Lessons Learned
- Navy Lessons Learned - Center for Excellence
- Best Manufacturing Practices
- DSMC EVM Department - Compliance Process
- Navy - World Class Practices
- Software Program Managers Network - BMP

### Continuing Education

- Technology Based Education
- Correspondence Courses
- Learning Resource Center
- DSMC Individual Learning Program (Electives)

### Coming Soon

- Search Engine Capabilities
- Electronic Forms

### Future Plans

- Faculty Bio Book
- Surveys and Survey Results
- Education Support

# Call for Papers

# *Acquisition Review Quarterly*

## — Special Issue on Managing Radical Change —

The *Acquisition Review Quarterly* (*ARQ*) is planning a special issue with the theme "Managing Radical Change." We are pleased to issue this call for papers!

Although the *ARQ* generally maintains an explicit focus on the Department of Defense, one purpose of this special issue is to reach beyond its usual pool of researchers—to seek scholarly theoretical contributions and well-researched empirical papers of a basic and exploratory nature that may not be strictly focused on defense acquisition. The term *acquisition* refers to the enterprise processes required for planning, procuring, implementing, managing, and maintaining major systems; this might include, for example, information systems, factory equipment, transportation and communication networks, intelligence and research processes, and other significant systems, in addition to defense weaponry. Every enterprise that engages in strategic and capital planning, procurement, project management, policy making, logistics, systems engineering, operations management, outsourcing, performance measurement, decision making, collaboration, and even marketing is involved with some form or stage of the acquisition process.

The focus of this special issue is on managing radical change, which has roots in the literature on business process reengineering, change management, new public management, organizational design, revolutionary economics, leadership, systems analysis, policy, quality, and others. This focus comes at a time in which many enterprises and organizations have now had some experience with the kinds of *radical* change and fundamental process redesign that are often used to contrast reengineering and innovation with the more incremental modes of change generally associated with Total Quality Management and continuous process improvement. The crumbling of the Berlin Wall, combined with acquisition reform, technological innovation and downsizing present tremendous challenges in terms of the defense acquisition process, and one objective might be to draw from research focused on industry to help address these challenges.

This special issue seeks descriptive and prescriptive theoretical work that can be applied to the acquisition process, along with rigorous empirical work with clear generalizations and implications for de-

fense acquisition. The *ARQ* is read by the most senior executives and policy makers in the government, so papers must have sufficient impact and importance to interest this group. We also seek to build a more solid theoretical foundation upon which acquisition research can build, so papers should be well-grounded in the appropriate literature, presented and formalized in a clear, concise, convincing and scientifically-defensible manner, and they should include compelling routes to generalization, replication, falsification and extension.

The *ARQ* is a refereed journal that is sponsored by the Department of Defense, and represents the leading source of executive and policy guidance pertaining to defense acquisition. This special issue will include professors David Lamm, Mark Nissen and Keith Snider, from the Naval Postgraduate School, as Guest Editors. Refereeing will be conducted in the usual double-blind process. Authors wishing to submit manuscripts should send them to the Editor of the *ARQ*, with a cover letter indicating that your paper is for this special issue, at the address below not later than 31 July 1997.

Manuscripts will be initially screened by the Editor of the *ARQ* to determine their appropriateness for review, and should not exceed 6,000 words. Articles must be printable within one issue; articles will not be printed in parts or in a continuing series. To ensure anonymity, each paper should be submitted with a separate page that includes the author(s)'s name(s) and complete address, and the paper should include the title, abstract, keywords, body, complete set of references, along with tables and figures at the end. Authors are reminded to not refer to themselves or to their own work directly in the paper. All *ARQ* publications must follow the *Publication Manual of the American Psychological Association* format, and potential authors may wish to consult a recent issue of the journal for reference.

If you have preliminary questions on submissions to this *ARQ* Special Issue, contact these Guest Editors:

Dr. David Lamm
(DLamm@nps.navy.mil; 408-656-2775)

Dr. Mark Nissen
(MNissen@nps.navy.mil; 408-656-3570)

Dr. Keith Snider
(KSnider@nps.navy.mil; 408-656-3621)

Naval Postgraduate School
555 Dyer Road, Code SM
Monterey, CA 93943-5000

To submit papers, mail them to:

Defense Systems Management College
Attn: DSMC Press (*ARQ*)
9820 Belvoir Road, Suite G38
Fort Belvoir, VA 22060-5565

Order Processing Code:
*5456

**Superintendent of Documents**
**Subscription Order Form**

*Charge your order. It's easy!* MasterCard VISA
**To fax your orders (202) 512-2250**

☐ YES, please send me ____ subscription(s) to the **Program Manager Magazine**, Defense Systems Management College, (PROM) at $11.00 ($13.75 foreign) each per year.

The total cost of my order is $_______. Price includes regular shipping and handling and is subject to change. International customers, please add 25%.

Company or personal name (Please type or print)

Additional address/attention line

Street address

City, State, Zip code

Daytime phone including area code

Purchase order number (optional)

**For privacy, check box below:**
❑ Do not make my name available to other mailers

**Check method of payment:**
❑ Check payable to Superintendent of Documents
❑ GPO Deposit Account
❑ VISA ❑ MasterCard (expiration date)

*Thank you for your order!*

Authorizing Signature 1/96

**Mail to:** Superintendent of Documents
P.O. Box 371954, Pittsburgh, PA 15250-7954

NEW SUBSCRIPTION

## FREE SUBSCRIPTIONS
# ACQUISITION REVIEW QUARTERLY (ARQ)

☐ Please add my name to your free subscription list.
☐ Please change my address.

Name and Title

Organization

Address (Home or Work)

( )
City State Zip Daytime Phone

CHANGE OF ADDRESS

**FEDERAL EMPLOYEES Can Receive a Free Subscription to**

# PROGRAM MANAGER (PM) and/or ACQUISITION REVIEW QUARTERLY (ARQ)

I am a federal employee (military or civilian) and want to add my name to your free subscription list.

☐ **PM**

☐ **ARQ**

☐ **BOTH**

Name and Title

Organization

Address (Home or Work)

( )
City State Zip Daytime Phone

AFFIX
POSTAGE
HERE

SUPERINTENDENT OF DOCUMENTS
P.O. BOX 371954
PITTSBURGH, PA 15250–7954

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

**BUSINESS REPLY MAIL**
**FIRST CLASS PERMIT NO. 12 FORT BELVOIR, VA**

**POSTAGE WILL BE PAID BY ADDRESSEE**

DEPARTMENT OF DEFENSE
DEFENSE SYST MGMT COLLEGE
ATTN DSMC PRESS
9820 BELVOIR ROAD
SUITE G38
FT BELVOIR VA 22060-9989

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

**BUSINESS REPLY MAIL**
**FIRST CLASS PERMIT NO. 12 FORT BELVOIR, VA**

**POSTAGE WILL BE PAID BY ADDRESSEE**

DEPARTMENT OF DEFENSE
DEFENSE SYST MGMT COLLEGE
ATTN DSMC PRESS
9820 BELVOIR ROAD
SUITE G38
FT BELVOIR VA 22060-9989